APPLICATION		
DASH NO.	NEXT ASSY	USED ON
-601		965-1176 965-1186 965-1206 965-1216

TITLE SHEET

INDEX

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ENGR	Peter Bateman	29-NOV-99	
MFG			
QA			
APVD	Lyle Kendall	29-NOV-99	
APVD			

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SCALE: NONE		SHEET 1 OF 147	

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		ADDED SHEETS						ADDED SHEETS			
SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR
ALL	D										

REVISIONS				
SH	REV	DESCRIPTION	DATE	APPROVED
ALL	**A**	**Details of each section's updates are listed in the Revision History at the beginning of each section. Changes made after the date of the previous revision were made as part of this revision.** **Reason: 01 Severity: 10**	**S. Wright** **J. Kistler**	**07-JUN-00**
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ALL	**C**	**Details of each section's updates are listed in the Revision History at the beginning of each section. Changes made after the date of the previous revision were made as part of this revision.** **Reason: 01 Severity: 10**	**G. Ostrom** **P. Hermann**	**05-JUL-01**
ALL	**D**	**Details of each section's updates are listed in the Revision History at the beginning of each section. Changes made after the date of the previous revision were made as part of this revision.** **Reason: 01 Severity: 10**	**N Paterson** **P. Hermann**	**31-JAN-02**

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1 Introduction

Revision History

		Effectivity	
Date - Modified By	**Description of the Updates**	**App.**	**Cfg.**
29-NOV-99 Peter Bateman	Initial Release and Entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4795: Added Envelope Modulation to EM6/8. Added commercial Modes 1, 3, 4 and 6 curves. General Document Cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
01-DEC-00 – Susie Wright	Doc only change - Lamp Format 2 plus general document cleanup for –006 release.	-006	-006
11-JUN-01 – P. Bateman	SCR 5991: Added Bizjet bank angle autopilot warning area.	-008	-008
11-JUN-01 – P. Bateman	SCR 5919: Added above field callout.	-008	-008
02-JUL-01 – S. Wright	SCR 4734: Added Honeywell windshear for BD-100 to 1.3.1.9	-008	-008
02-JUL-01 – S. Wright	Added review comments.	-008	-008

ENHANCED GROUND PROXIMITY WARNING COMPUTER

1.0 Document Overview

This document is organized as follows.

Section 1	Introduction, identifies this product specification, gives an overview of the EGPWS, and describes the content and organization of this document.
Section 2	Referenced Documents, listed by document number, title, and source, all documents that are referenced in this specification.
Section 3	Computer Design Criteria, identifies the design, environmental, and regulatory standards that will be used to measure the performance of the EGPWS.
Section 4	External Interface, refer to the Installation Design Guide.
Section 5	Functional Inputs, describes each of the functions external system inputs used in the EGPWS.
Section 6	System Functions, describes each of the system functions included in the EGPWS.
Appendix A	Definitions and Symbols, contains lists of acronyms used in this document.

1.1 Part Number

This document is the Product Specification for the Enhanced Ground Proximity Warning System (EGPWS), Honeywell part numbers:

965-1176-xxx: MKVI EGPWC
965-1186-xxx: MKVI EGPWC with Internal GPS
965-1206-xxx: MKVIII EGPWC
965-1216-xxx: MKVIII EGPWC with Internal GPS

Differences, where they exist, between the different part numbers, are highlighted within this document.

The 965-1176-xxx series part number MKVI EGPWCs are intended for turboprop aircraft that provide a mixture of limited analog and digital interfaces. Display support includes several weather radar indicators and limited EFIS support. The terrain database included with the EGPWC is regional. See Figures 1.3.2-2, -3 and -4 for regions.

The 965-1186-xxx series part number MKVI EGPWCs include an internal GPS-PXPRESS card and are otherwise as 965-1176-xxx.

The 965-1206-xxx series part number MKVIII EGPWCs are intended for regional turboprop and turbofan aircraft that provide a mixture of limited analog and digital signal interfaces. Display support includes several weather radar indicators and limited EFIS support. The terrain database included with the EGPWC is global.

The 965-1216-xxx series part number MKVIII EGPWCs include an internal GPS-PXPRESS card and are otherwise as 965-1206-xxx.

In order to minimize complexity, the EGPWC utilizes a 10 digit part number. This 10 digit part number will identify the configuration of the EGPWC, which affects form, fit, or function as seen by the pilot. This part number is defined as follows:

- 965-1ABC-DDD (example 965-1176-001)
- A = 1 (EMVI) or 2 (EMVIII)
- B = 7 (EMVI without internal GPS) or 8 (EMVI with internal GPS) or 0 (EMVIII without internal GPS) or 1 (EMVIII with internal GPS
- C = MK VI or MK VIII EGPWC Hardware (including boot code). C = 6, 7, 8, 9 as hardware part numbers roll.
- DDD = Application software (including configuration software)
- Terrain Database(including the Envelope Modulation Database)- Version not identified in 10-digit part number but with a separate identifier.
- Modifications - All modifications will be identified via “mod dots”. No mod dots will be skipped.

The digits identifying the application software will match the respective version number of the application software.

See section 6.10.11 for details on configuration management.

1.2 Purpose

The Product Specification describes all of the system functions and design criteria for the MKVI and MKVIII Enhanced Ground Proximity Warning System (EGPWS). This document serves two major purposes. First, it describes the system functions for EGPWS customers. Secondly, it provides a system description for regulatory authorities.

1.3 System Overview

The purpose of the Enhanced Ground Proximity Warning System is to help prevent accidents caused by Controlled Flight into Terrain (CFIT). The system achieves this objective by accepting a variety of aircraft parameters as inputs, applying alerting algorithms, and providing the flight crew with aural alert messages and visual annunciations and displays in the event that the boundaries of any alerting envelope are exceeded. Figure 1.3-1 provides an overall system block diagram.

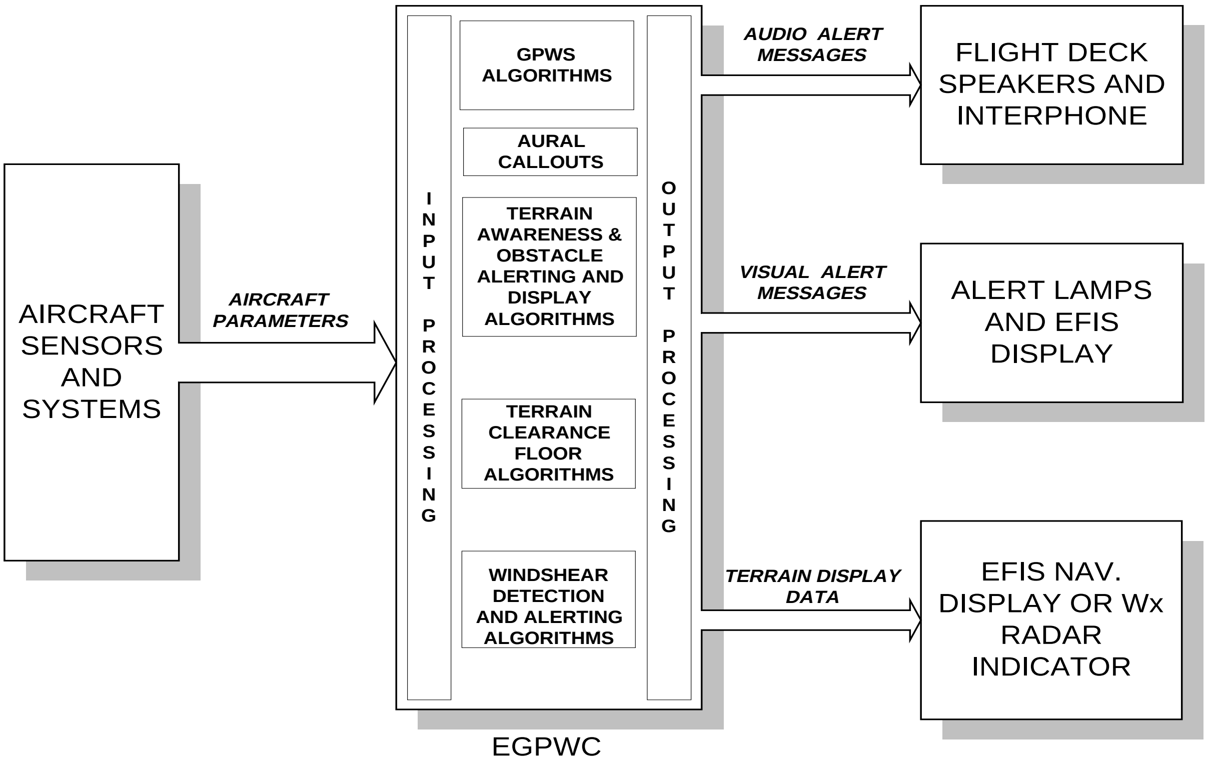

FIGURE 1.3-1: ENHANCED GROUND PROXIMITY WARNING SYSTEM

The system comprises the following groups of components:

- Aircraft sensors and other systems providing input signals
- The Enhanced Ground Proximity Warning Computer (EGPWC)
- Flight deck audio systems (speakers and interphone)
- Alert (caution and warning) lamps and/or digital outputs to EFIS displays (for alert and system status messages)
- Weather radar indicator for display of terrain and limited EFIS display support.
- Switching relay(s) or Display Switching Unit (DSU) when required for switching display inputs from weather display to terrain display.

The system is designed to be fully compatible with normal operations of commercial aircraft: unwanted alerts will be very rare if the flight crew maintains situational awareness with respect to the terrain and if the crew follows correct avoidance procedures for any significant windshear activity.

Several main alerting functional areas are integrated into the EGPWC, which is a single Line Replaceable Unit (LRU). Each function is configuration module selectable.

The functional areas are:

- Basic Ground Proximity Warning
- Altitude Awareness Callouts
- Excessive Bank Angle Alert
- Enhanced features, Terrain and Obstacle Awareness alerts and warnings as well as optional display of this information, "Peaks" mode, and Terrain Clearance Floor.
- WS Detection and Alerting (limited application).

The basic Ground Proximity Warning (GPW) function is the backbone of the system, and the primary design objective has been to maintain the integrity of this function independent of the other functions. For example, loss of the Terrain Awareness display function will not affect the operation of the GPW functions (provided that the input signals necessary for GPW operation are still available).

In addition to the main alerting functions, the computer also performs the following auxiliary functions:

- Input signal processing (including filtering and signal monitoring).
- Alert output processing (including alert prioritization, voice message synthesis, audio output and display and caution or warning lamp drivers)
- Built In Test and monitoring including cockpit-activated self test.
- PCMCIA interface for uploading software and databases (using a Smart Cable).
- Front panel maintenance test connector for system checkout and troubleshooting.
- System status LED's located on the LRU front panel to indicate external fault, computer O.K. and computer fail conditions.

1.3.1 Ground Proximity Warning

As shown in Figure 1.3.1-1, the EGPWS provides the basic Ground Proximity Warning System (GPWS) alerting in six modes.

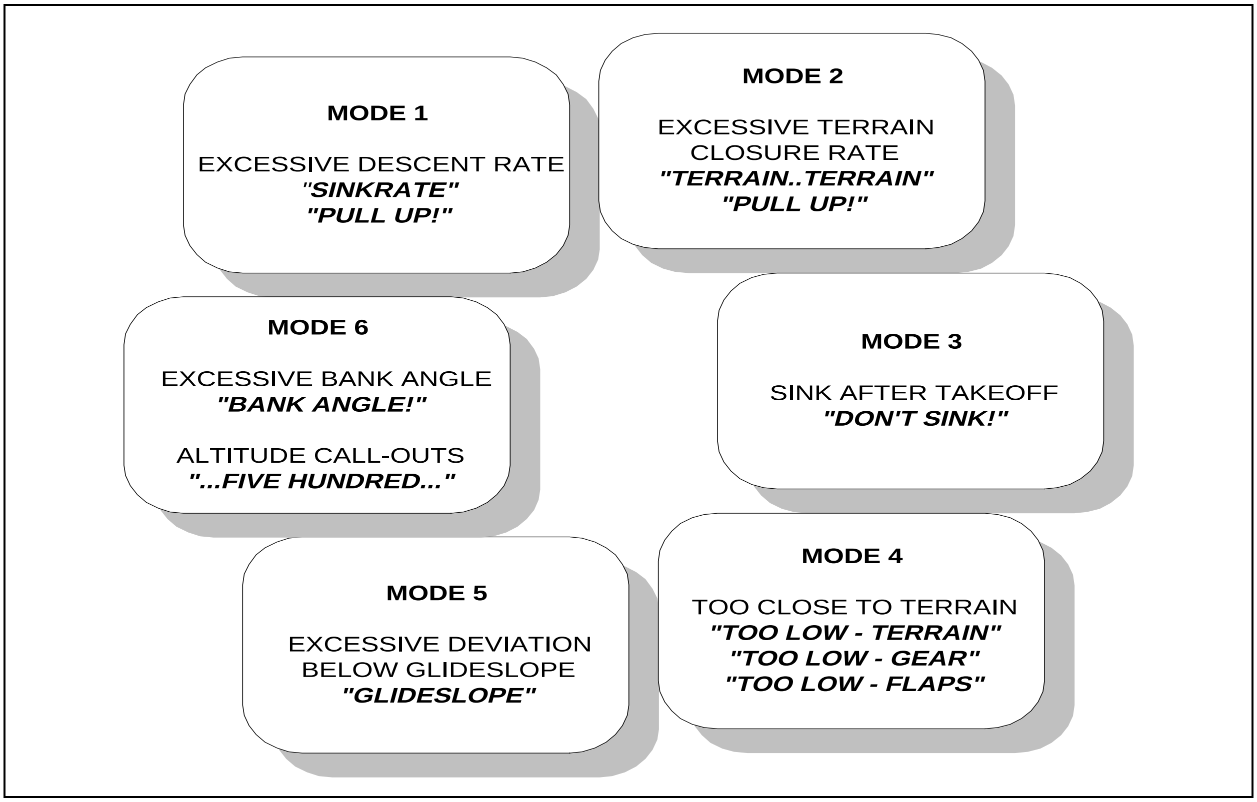

FIGURE 1.3.1-1: GROUND PROXIMITY WARNING MODES

Modes 1 through 5 are in accordance with the requirements of TSO-C92c, TSO-C151a, DO-161A, C117a, CAA Spec 14 and ICAO Annex 6. Mode 6 provides additional protection in the form of a selectable menu of radio altitude callouts during landing approach, and an optional alert for excessive bank angle. (It should be noted that the numbering of the modes is derived from the history of the development of GPWS, and does not imply any special hierarchy).

The basic GPW modes are tailored for the application by selection of various options, which are configuration module selectable during installation of the EGPWC. An overview of the functioning of each of the GPW modes is given in the following paragraphs. Full details of the operation of the modes are given in section 6.2.

An audio declutter feature is standard which activates the voice alert once, then not again unless the situation has degraded by 20%. This feature applies to modes 1, 3, 4, and 5.

1.3.1.1 Mode 1 - Excessive Descent Rate

Mode 1 provides alerts when the aircraft has excessive descent rate close to the terrain (see Figure 1.3.1.1-1 and 1.3.1.1-2). Figure 1.3.1.1-1 shows the turboprop curves, available on MKVI and MKVIII EGPWS. Figure 1.3.1.1-2 shows the turbofan curves, available on MKVIII EGPWS only and selectable at the time of installation.

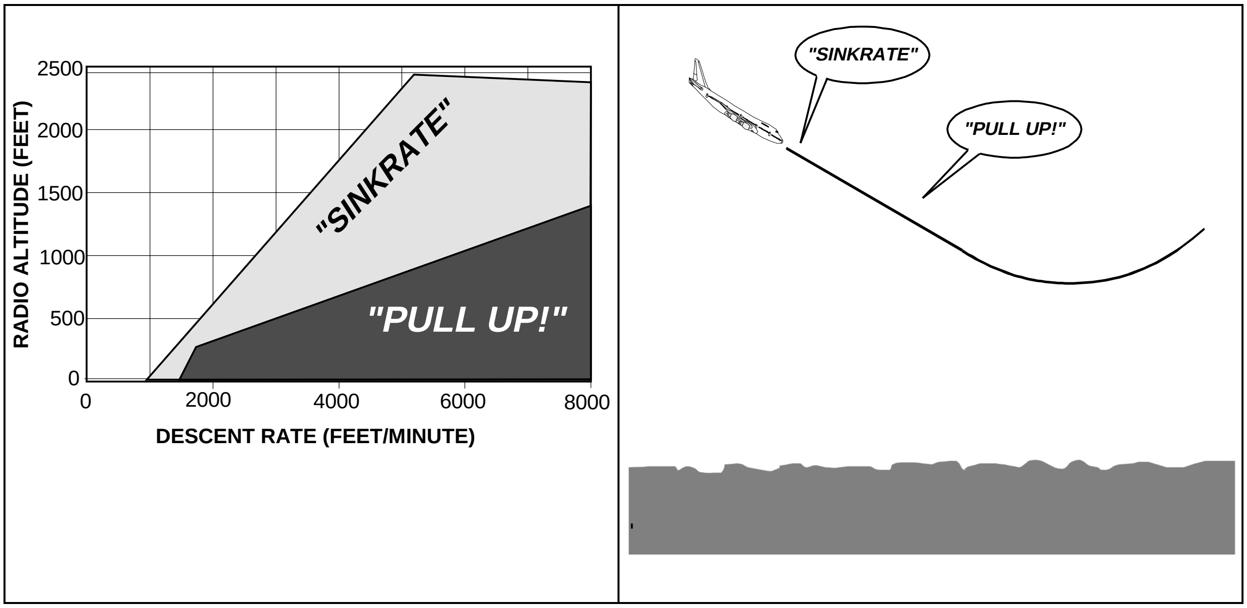

FIGURE 1.3.1.1-1: MODE 1 - EXCESSIVE DESCENT RATE (TURBOPROP)

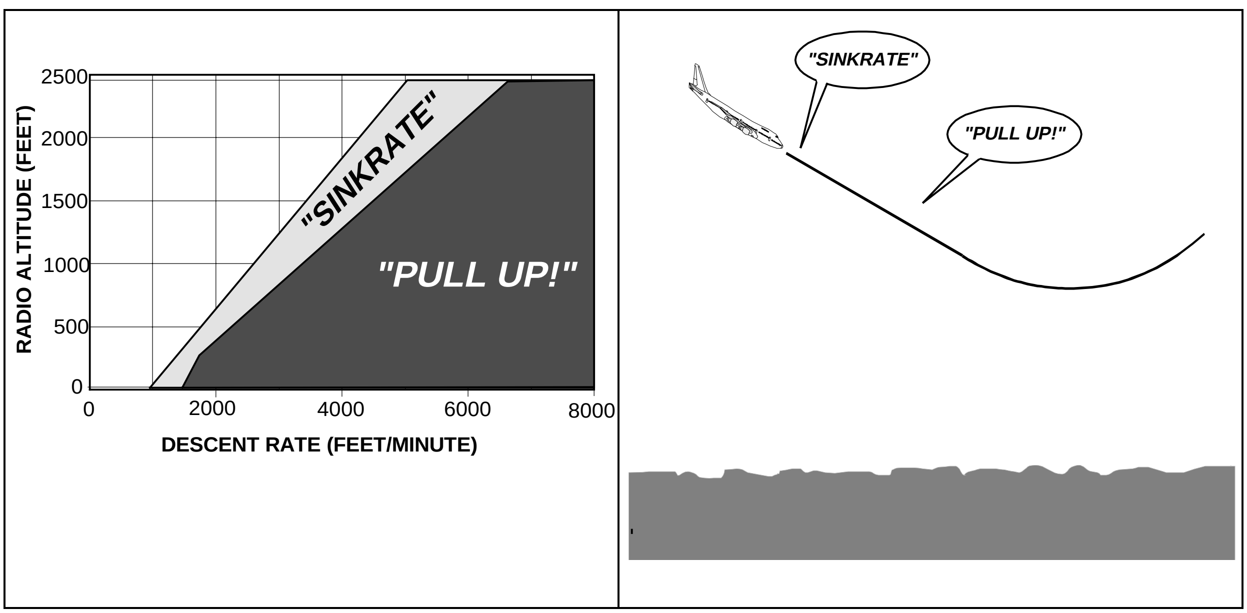

FIGURE 1.3.1.1-2: MODE 1 - EXCESSIVE DESCENT RATE (TURBOFAN)

If the aircraft penetrates the "outer" alert boundary, the aural message *"Sinkrate"* is generated, and alert discretes are output by the computer for driving visual annunciators. If the aircraft penetrates the "inner" alert boundary, the aural message *"Pull Up!"* is generated and visual alert discretes are also output. The alert boundaries are defined in terms of aircraft vertical speed (barometric altitude rate) and radio altitude.

Improvements to the Mode 1 alert boundaries are as follows:

- Envelope Modulation - (see paragraph 1.3.1.7)
- Glideslope Deviation Bias - The "outer" alert boundary *("Sinkrate")* is desensitized when the aircraft is above the glideslope beam. This prevents unwanted alerts when the aircraft is safely capturing the glideslope (or repositioning to the centerline) from above the beam.
- Steep Approach Bias - If steep approach is enabled by configurable item then it changes the alert boundaries to permit safe, but steeper than normal, instrument precision approaches (e.g. MLS or GPS approaches) without unwanted alerts.
- Flap Override Bias – If flap override is selected by input discrete, it changes the alert boundaries to permit potentially higher descent rates resulting from flaps not being set to "landing" during approaches. This bias is smaller than the steep approach bias.

1.3.1.2 Mode 2 - Excessive Terrain Closure Rate

Mode 2 provides alerts when the aircraft is closing with the terrain at an excessive rate. It is not necessary for the aircraft to be descending in order to produce a Mode 2 alert, level flight (or even a climb) towards obstructing terrain can result in hazardous terrain closure rate. The terrain closure rate variable is computed within the EGPWS computer by combining radio altitude and vertical speed in a non-linear complementary filter.

Mode 2 has two sub-modes, referred to as Mode 2A and Mode 2B, the active sub-mode being determined by aircraft configuration. The Mode 2A alerting envelope is illustrated in Figure 1.3.1.2-1, and the Mode 2B envelope is shown in Figure 1.3.1.2-2.

When TA&D, TCF and Geometric Altitude functions are enabled and of high integrity, certain Mode 2 functions are safely reduced to the TSO minimums or placed in ILS Mode 2B operation.

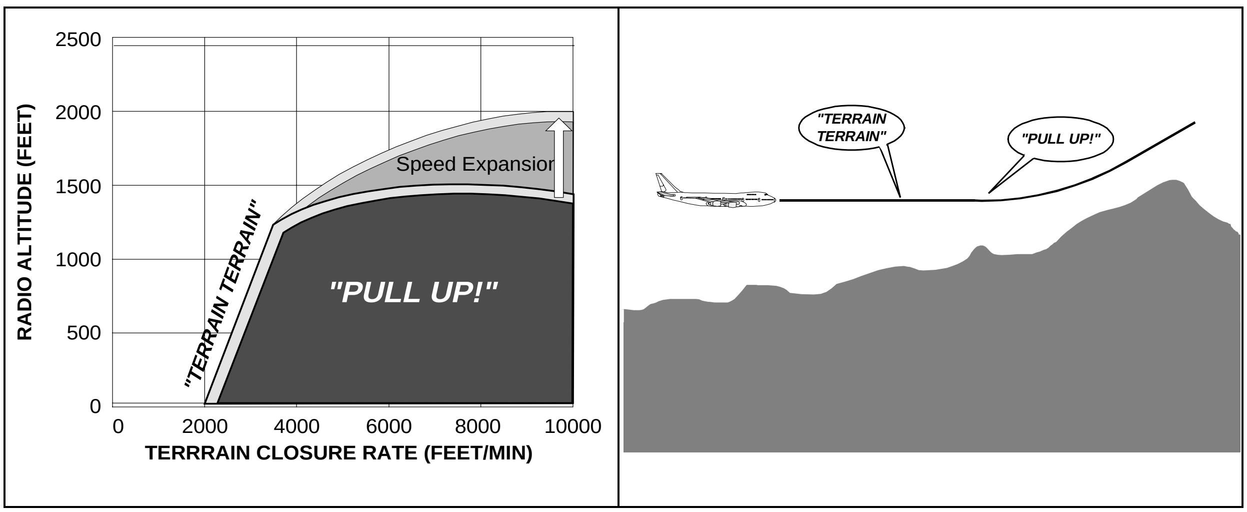

FIGURE 1.3.1.2-1: MODE 2A - EXCESSIVE TERRAIN CLOSURE RATE

Mode 2A is enabled when the conditions for enabling Mode 2B are not satisfied (see below). If the aircraft penetrates the Mode 2A alerting envelope, the aural message "*Terrain Terrain*" is generated initially, and alert discretes are output for driving visual annunciators. If the aircraft continues to penetrate the envelope, then the aural message "*Pull Up!*" is repeated continuously until the warning envelope is exited. At this point, an altitude gain function, described in section 6.2.2.2, activates. The aural message reverts to "*Terrain, Terrain...*", but will only be given if the terrain clearance continues to decrease. The visual alert will remain on until either the aircraft has gained 300 feet of barometric altitude, or 45 seconds has elapsed, or the altimeter loses track. At that point all visual alerts stop. As shown in Figure 1.3.1.2-1, the upper boundary of the Mode 2A alert envelope varies as a function of aircraft speed. As airspeed increases from 220 knots to 310 knots, the boundary expands to provide increased alert times at higher airspeeds.

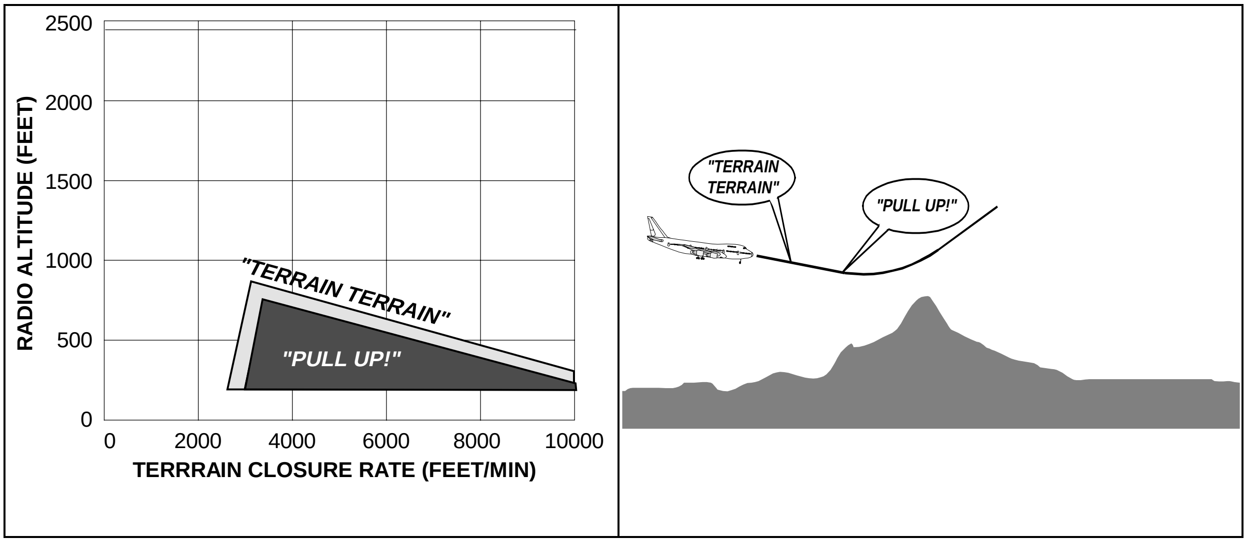

FIGURE 1.3.1.2-2: MODE 2B - EXCESSIVE TERRAIN CLOSURE RATE

Mode 2B provides a "desensitized" alert envelope, permitting normal landing approach maneuvering close to the terrain without producing unwanted alerts. Mode 2B is enabled for three conditions:

- Whenever flaps are selected to the landing position
- If the aircraft is performing an ILS approach and is within ±2 dots of the glideslope centerlines
- For the first 60 seconds after takeoff

If the aircraft penetrates the Mode 2B envelope with either gear or flaps not in landing configuration, the aural message *"Terrain, Terrain"* is generated initially, and alert discretes are output for driving visual annunciators. If the aircraft continues to penetrate the envelope, then the aural message *"Pull Up!"* is repeated continuously until the warning envelope is exited. If the aircraft penetrates the Mode 2B envelope with both gear and flaps in landing configuration, the aural message *"Terrain...."* is repeated until the envelope is exited.

Envelope modulation, as described in section 1.3.1.7, is used to eliminate, whenever possible, operationally-induced unwanted warnings.

1.3.1.3 Mode 3 - Altitude Loss After Takeoff

Mode 3 provides alerts when the aircraft loses a significant amount of altitude immediately after takeoff or during a missed approach, as shown in Figures 1.3.1.3-1 and 1.3.1.3-2. Figure 1.3.1.3-1 shows the turboprop curve, available on MKVI EGPWS and MKVIII EGPWS. Figure 1.3.1.3-2 shows the turbofan curve, available on MKVIII EGPWS only and selectable at the time of installation.

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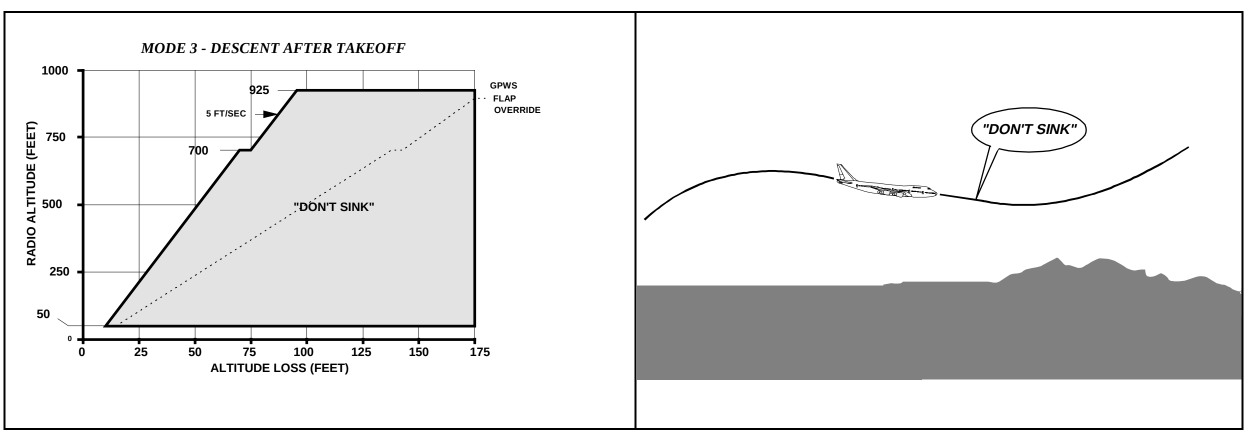


FIGURE 1.3.1.3-1: MODE 3 - ALTITUDE LOSS AFTER TAKEOFF (TURBOPROP)

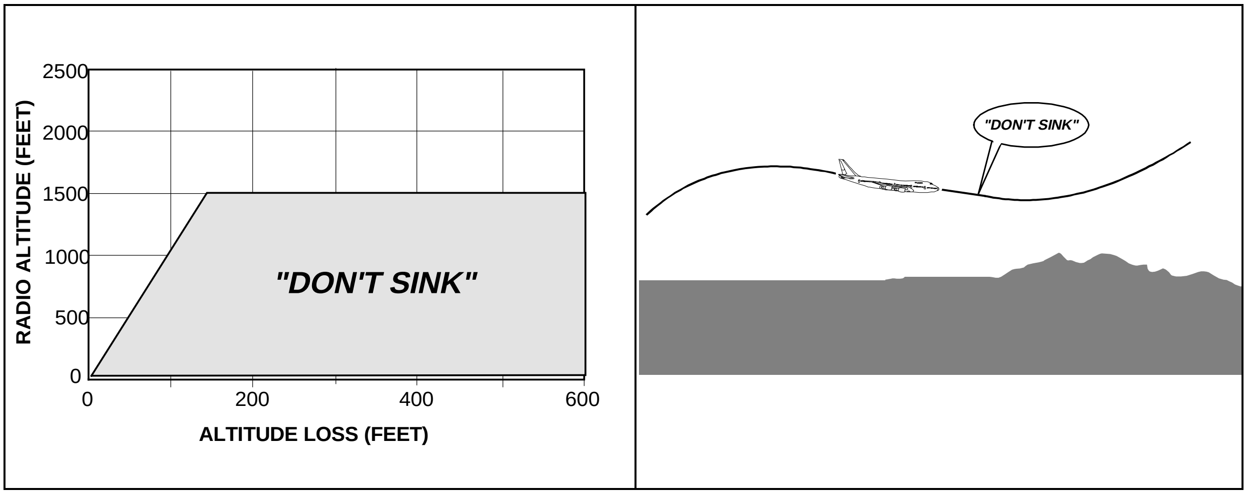


FIGURE 1.3.1.3-2: MODE 3 - ALTITUDE LOSS AFTER TAKEOFF (TURBOFAN)

The altitude loss variable is based on the change of altitude (MSL) from the beginning of the inadvertent descent. The amount of altitude loss, which is permitted before an alert is given, is a function of the height of the aircraft above the terrain, as shown in Figures 1.3.1.3-1 and 1.3.1.3-2. Mode 3 is enabled after takeoff or go around, when landing gear or flaps are not in landing configuration. It stays enabled until the EGPWC detects that the aircraft has gained sufficient altitude that it is no longer in the takeoff phase of flight.

Selecting flap override increases the allowable altitude loss as shown in Figure 1.3.1.3-1. This allows optional pattern work to be performed without unwanted warnings. An additional biasing, or modifying of the envelope occurs above 700 feet AGL at the rate of 5 feet additional altitude loss allowed per second.

If the aircraft penetrates the Mode 3 boundary, the aural message *"Don't Sink"* is generated, and alert discretes are provided for activation of visual annunciators. The visual annunciators remain active until a positive rate of climb is re-established.

1.3.1.4 Mode 4 - Unsafe Terrain Clearance

Mode 4 provides alerts for insufficient terrain clearance with respect to phase of flight and speed. Mode 4 exists in three forms, 4A, 4B and 4C. Mode 4A is active during cruise and approach with gear not in landing configuration. Mode 4B is also active in cruise and approach, but with gear in landing configuration. Mode 4C is active during the takeoff phase of flight with either gear or flaps not in landing configuration.

As shown in Figures 1.3.1.4-1 the standard boundary for Mode 4A is at 500 feet radio altitude. If the aircraft penetrates this boundary with the gear still up, the voice message will be *"Too Low Gear"*. The same boundary is used to produce a *"Too Low Flaps"* message if this boundary is penetrated with flaps still up in fixed gear aircraft. Above 178 knots, the boundary increases linearly with airspeed to a maximum of 750 feet radio altitude at 200 knots or more. An alternate airspeed expansion range, activated by a configuration item in the configuration module, begins at 148 knots and ends at 170 knots for slower aircraft. Penetrating this boundary produces a *"Too Low Terrain"* message.

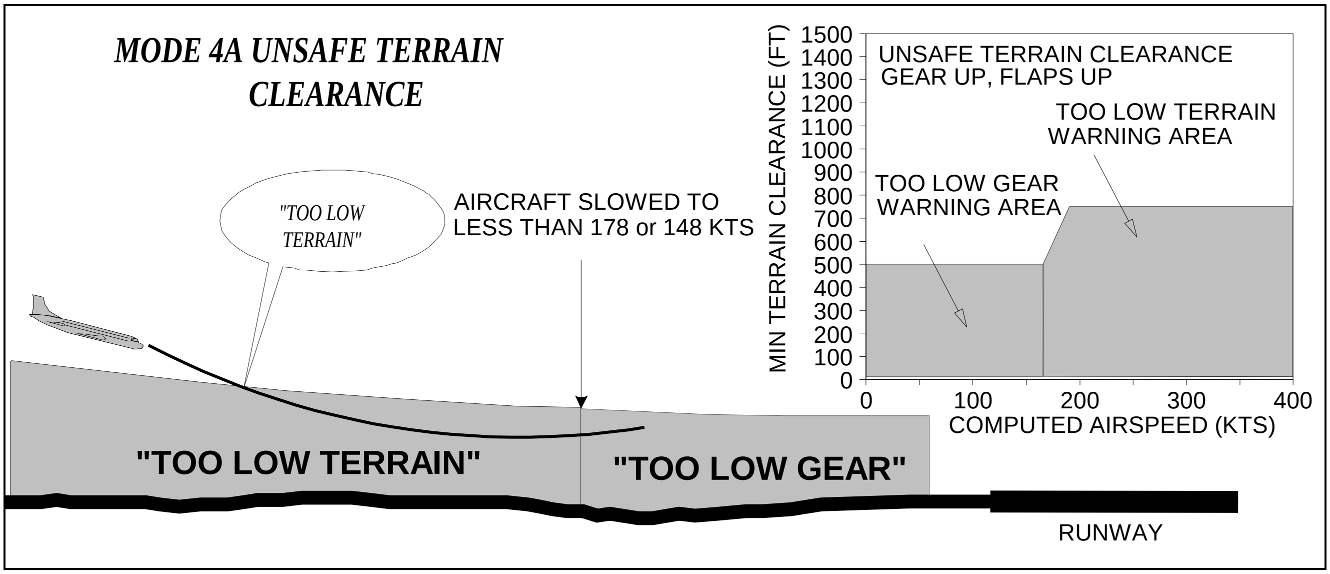


FIGURE 1.3.1.4-1: MODE 4A - UNSAFE TERRAIN CLEARANCE - GEAR UP (TURBOPROP)

Mode 4 curves with specific application for turbofan aircraft are available on the MKVIII EGPWS. As shown in Figures 1.3.1.4-2 the standard boundary for Mode 4A for this curve is at 500 feet radio altitude. If the aircraft penetrates this boundary with the gear still up, the voice message will be *"Too Low Gear"*. The same boundary is used to produce a *"Too Low Flaps"* message if this boundary is penetrated with flaps still up in fixed gear aircraft. Above 190 knots the boundary increases linearly with airspeed to a maximum of 1000 feet radio altitude at 250 knots or more. Penetrating this boundary produces a *"Too Low Terrain"* message.

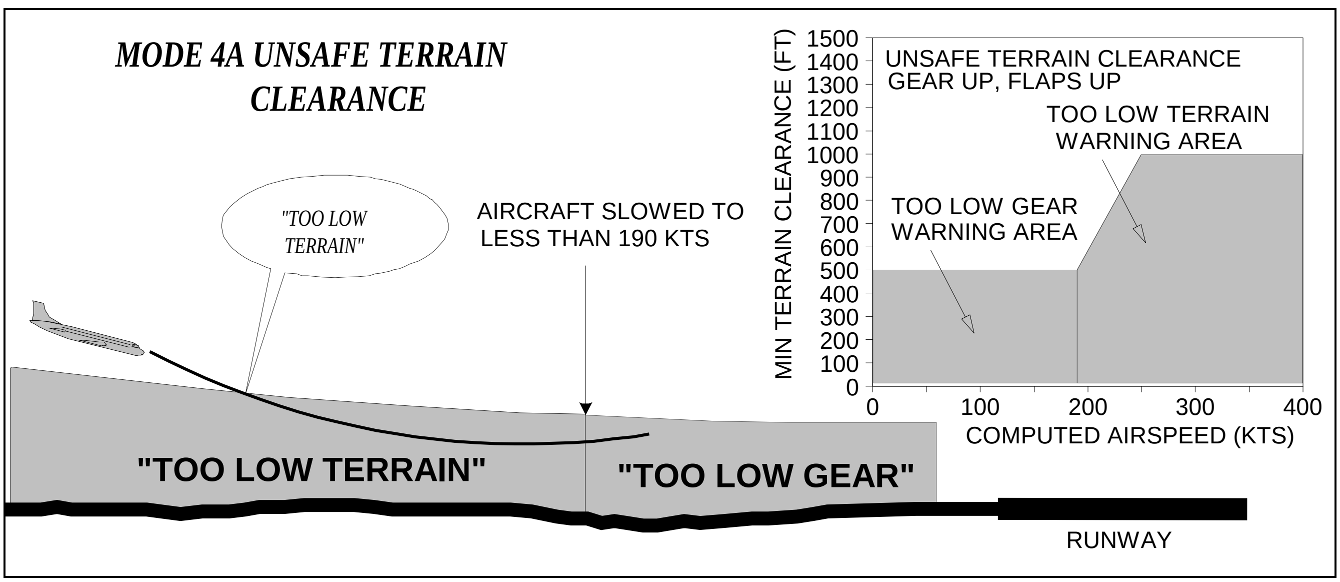


FIGURE 1.3.1.4-2: MODE 4A - UNSAFE TERRAIN CLEARANCE - GEAR UP (TURBOFAN)

When the landing gear is lowered, Mode 4B becomes active and the boundary decreases to 170 feet for turboprop aircraft. This is reduced to 150 feet on those aircraft types that routinely delay full flap deployment until the airfield is within approximately one nautical mile (enabled by a configuration item in the configuration module). In addition, an optional curve (enabled by a configuration item in the configuration module) places the upper boundary at 200 feet. Penetration below 150 knots results in the *"Too Low Flaps"* message with gear down and flaps not in landing configuration, while above 150 knots the message is *"Too Low Terrain"*. Mode 4B is illustrated in Figure 1.3.1.4-3.

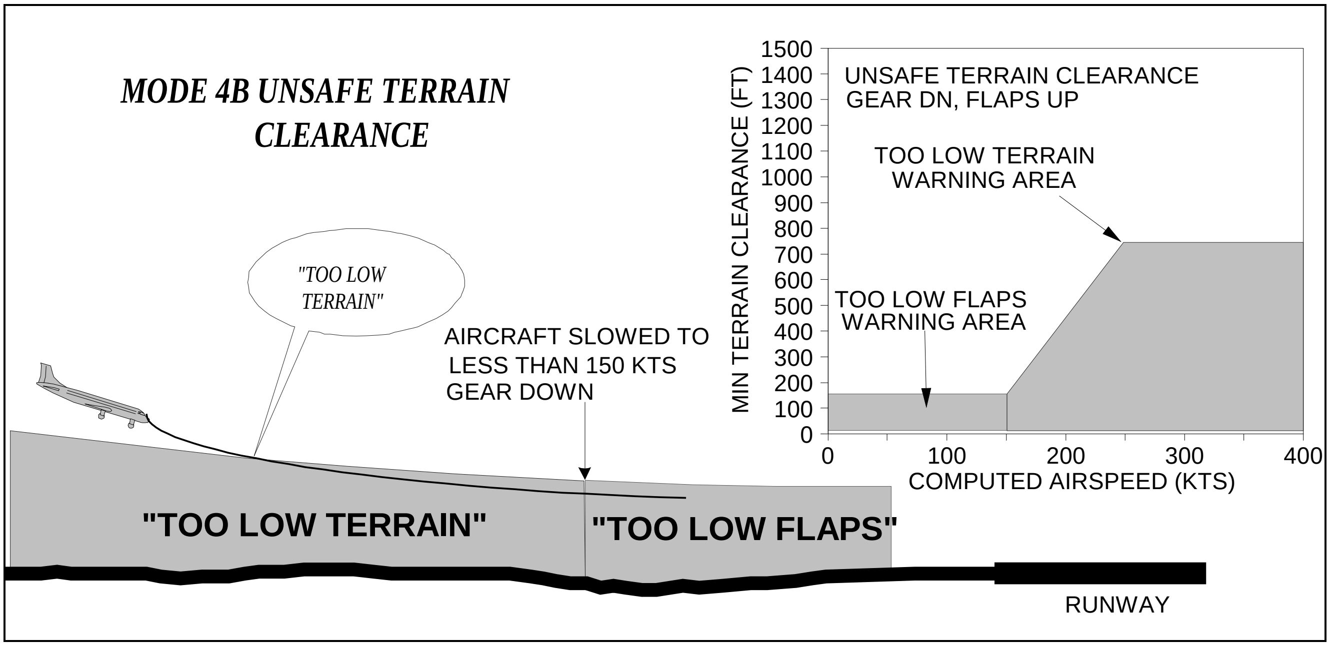


FIGURE 1.3.1.4-3: MODE 4B - UNSAFE TERRAIN CLEARANCE - GEAR DOWN (TURBOPROP)

The Mode 4B curve associated with turbofan aircraft is available on the MKVIII EGPWS. When the landing gear is lowered, this mode becomes active and the boundary decreases to 245 feet. Penetration below 159 knots results in the *"Too Low Flaps"* message with gear down and flaps not in landing configuration, while above 159 knots the message is *"Too Low Terrain"*. Mode 4B is illustrated in Figure 1.3.1.4-4.

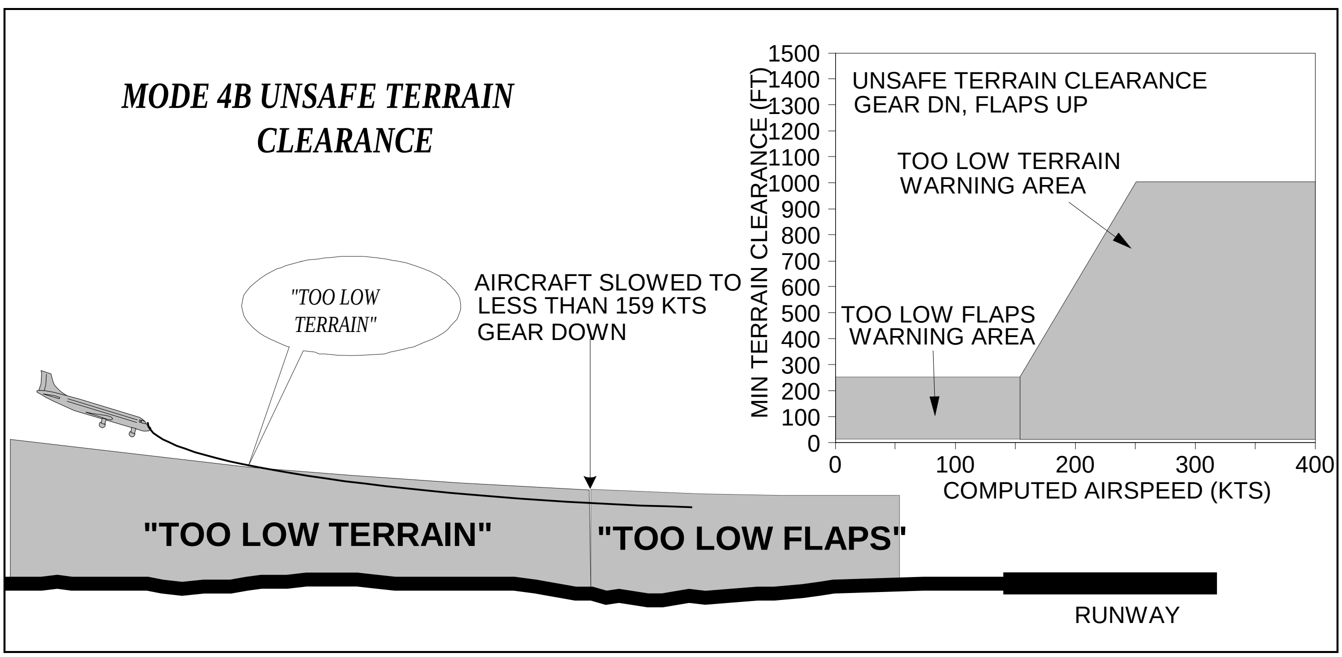


FIGURE 1.3.1.4-4: MODE 4B - UNSAFE TERRAIN CLEARANCE - GEAR DOWN (TURBOFAN)

Mode 4C is based on a minimum terrain clearance, or floor, that increases with radio altitude during takeoff. A value equal to 75% of the current radio altitude is accumulated in a long-term filter. Any decrease of radio altitude below the filter value with gear or flaps up will result in the warning *"Too Low Terrain"*. Mode 4C for turboprops is illustrated in Figure 1.3.1.4-5, and Mode 4C for turbofans is illustrated in Figure 1.3.1.4-6.

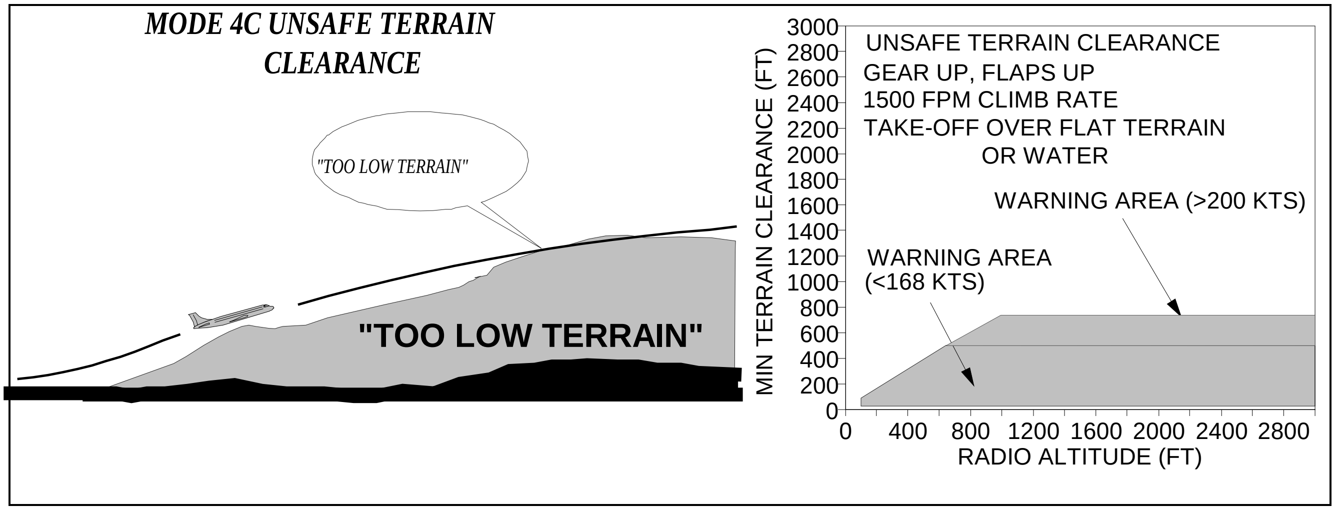


FIGURE 1.3.1.4-5: MODE 4C - UNSAFE TERRAIN CLEARANCE - AT TAKEOFF (TURBOPROP)

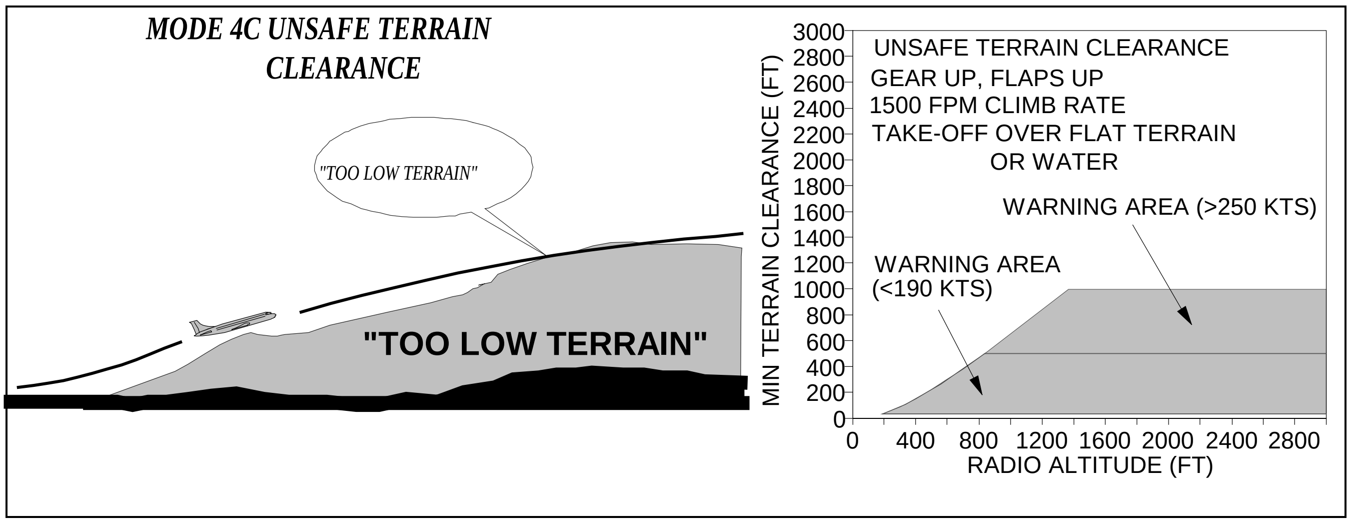


FIGURE 1.3.1.4-6: MODE 4C - UNSAFE TERRAIN CLEARANCE - AT TAKEOFF (TURBOFAN)

Optional variations to the Mode 4 alert boundaries are available through Envelope Modulation, as described in section 1.3.1.7. When Terrain Awareness is enabled, the Mode 4 A/B *"Too Low Terrain"* voice is limited to values below the *"Too Low Flaps"* voice.

1.3.1.5 Mode 5 - Below Glideslope

Mode 5 provides two levels of alerting when the aircraft flight path descends below the glideslope beam on front course ILS approaches. The first alert activation occurs whenever the aircraft is more than 1.3 dots below the beam and is called a "soft" glideslope alert because the volume level of the "Glideslope" alert is approximately one half (-6 dB) that of the other alerts. A second alert boundary occurs below 300 feet radio altitude with greater than 2 dots deviation and is called "loud" or "hard" glideslope alert because the volume level is increased to that of the other alerts. Mode 5 is illustrated in Figure 1.3.1.5-1.

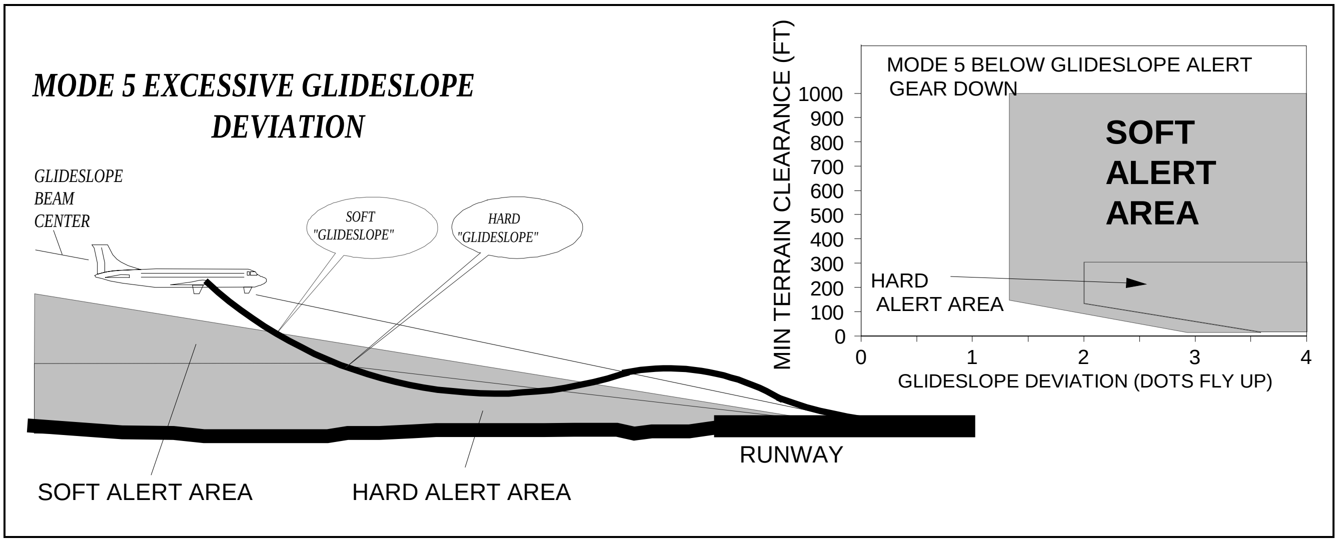


FIGURE 1.3.1.5-1: MODE 5 - EXCESSIVE GLIDESLOPE DEVIATION

Other variations to the Mode 5 alert boundaries are as follows:

- Envelope Modulation, as described in section 1.3.1.7
- Localizer intercept, as described in section 6.2.5 (note: localizer is not a basic input, and is only available when digitally sourced).
- Level flight intercept

1.3.1.6 Mode 6 – Altitude Call-Outs

Mode 6 provides audio callouts for descent below predefined altitudes and minimums as shown in Figure 1.3.1.6-1. Excessive bank angle warnings, including a reduction of threshold if the autopilot is engaged, are also provided as part of this mode as shown in Figures 1.3.1.6-2 (available on MKVI and MKVIII EGPWS) and 1.3.1.6-3 (available on MKVIII EGPWS only). The “Bank Angle” aural warning is given twice, and then suppressed unless the roll angle increases by an additional 20%.

Specific callouts are selectable via configuration items in the configuration module from predefined menus. Mode 6 callouts produce aural output indications, but do not produce visual indications.

A “smart five hundred” foot callout is available. This callout will only be issued when the system detects that a non-precision approach is being performed or that the aircraft is outside ±2 dots glideslope deviation.

A callout is available indicating 500 feet above runway field. This is based upon geometric altitude.

A “minimums-minimums” callout is provided based upon the decision height discrete.

An optional discrete input provides the ability to force the Mode 6 audio level to lower audio volume. This enables operators to control the Mode 6 volume level with activation of windscreen rain removal or if lower volume callouts are desired at all times.

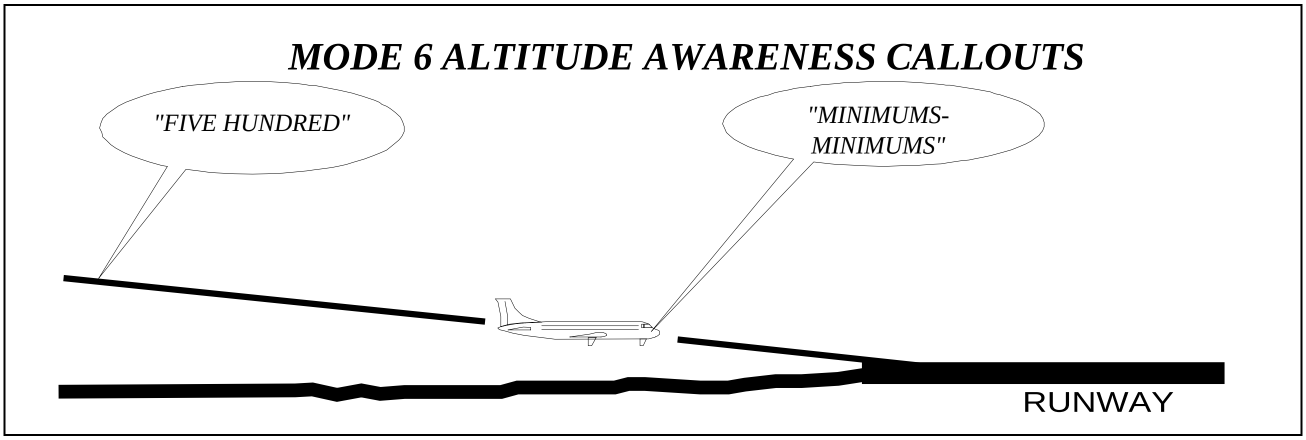


FIGURE 1.3.1.6-1: MODE 6 ALTITUDE CALLOUTS

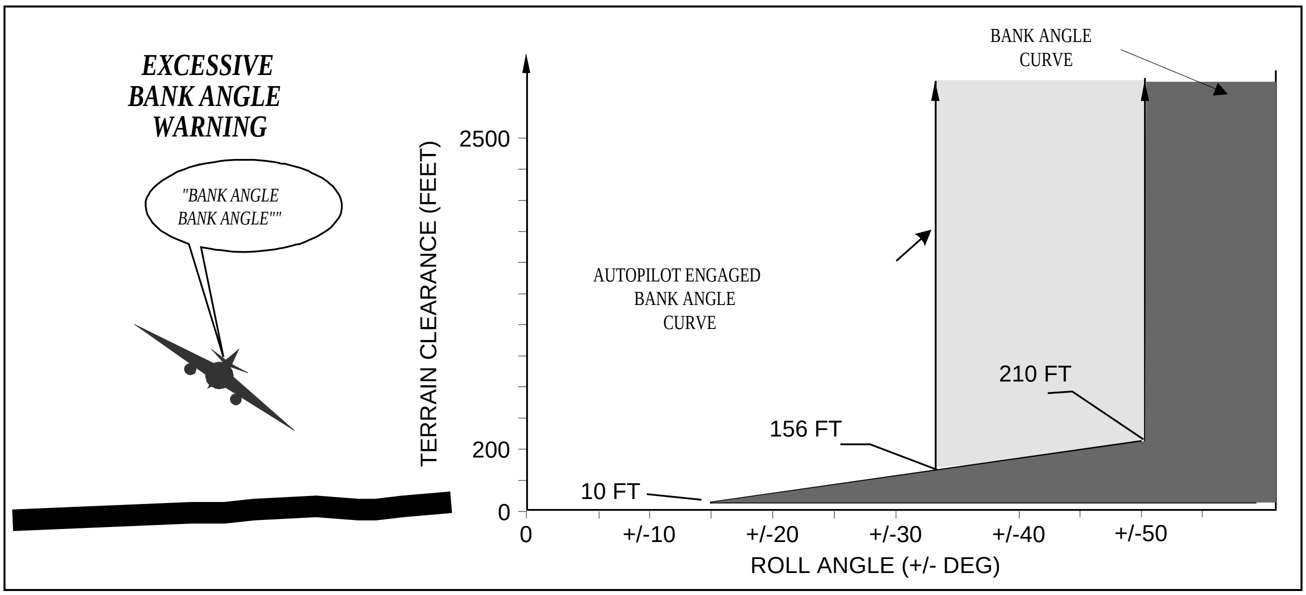


FIGURE 1.3.1.6-2: EXCESSIVE BANK ANGLE (TURBOPROP)

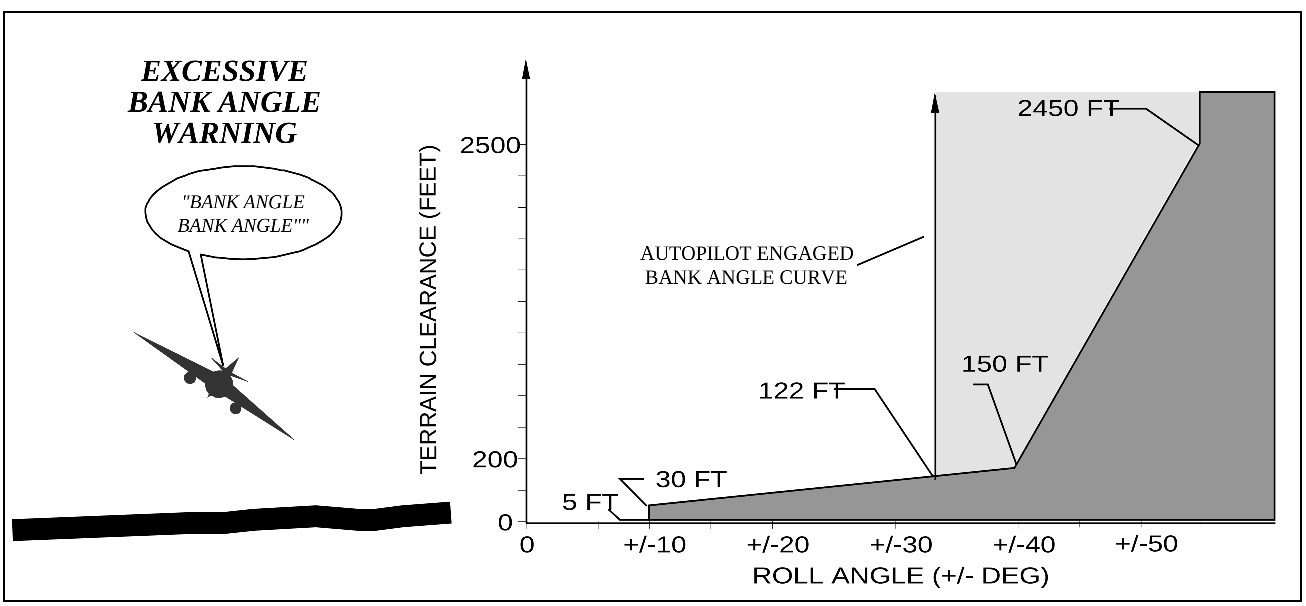


FIGURE 1.3.1.6-3: EXCESSIVE BANK ANGLE (TURBOFAN)

1.3.1.7 Envelope Modulation

The Envelope Modulation feature provides improved alerting protection at some key locations throughout the world, while improving nuisance margins at others. This is made possible with the use of navigational signals from GPS. All position data is cross checked to ground based navigational aids, altimeter and heading information, and stored terrain characteristics prior to being accepted for Envelope Modulation purposes.

Modes 4, 5, and 6 are expanded at some locations to provide alerting protection consistent with normal approaches. Modes 1, 2, and 4 are desensitized at other locations to prevent nuisance warnings that result from unusual terrain or approach procedures. In all cases, very specific information is used to correlate the aircraft position and phase of flight prior to modulating the envelopes. The tables that store the Envelope Modulation data are maintained in non-volatile memory.

1.3.1.8 Terrain Clearance Floor

The Terrain Clearance Floor (TCF) alert, illustrated in Figure 1.3.1.8-1, adds an additional element of protection to the standard Ground Proximity Warning modes. It creates an increasing terrain clearance envelope around the intended airport runway directly related to the distance from the runway. TCF alerts are based on current aircraft location, radio altitude and a distance based upon nearest runway center point position minus half the runway length. TCF is active during takeoff, cruise and final approach. This alert mode complements existing Mode 4 protection by providing an alert based on insufficient terrain clearance even when in landing configuration.

A Runway Field Clearance Floor alert is also provided for runways that are located on top of a hill. This alert is similar to the TCF alert, but is based on field clearnace (height above runway) instead of radio altitude. More details on this can be found in section 6.3.1.3 of this document.

TCF Alerts illuminate MKVI/MKVIII EGPWS cockpit lamps and produce the aural message *"Too Low Terrain"*. This aural message will occur once when the initial envelope penetration occurs, and one time thereafter for each 20% degradation in radio altitude. EGPWS caution lamps (or warning lamps if using Lamp Format 1) will remain on until the alert envelope is exited. Further details can be found in seciton 6.3.1.3 of this document.

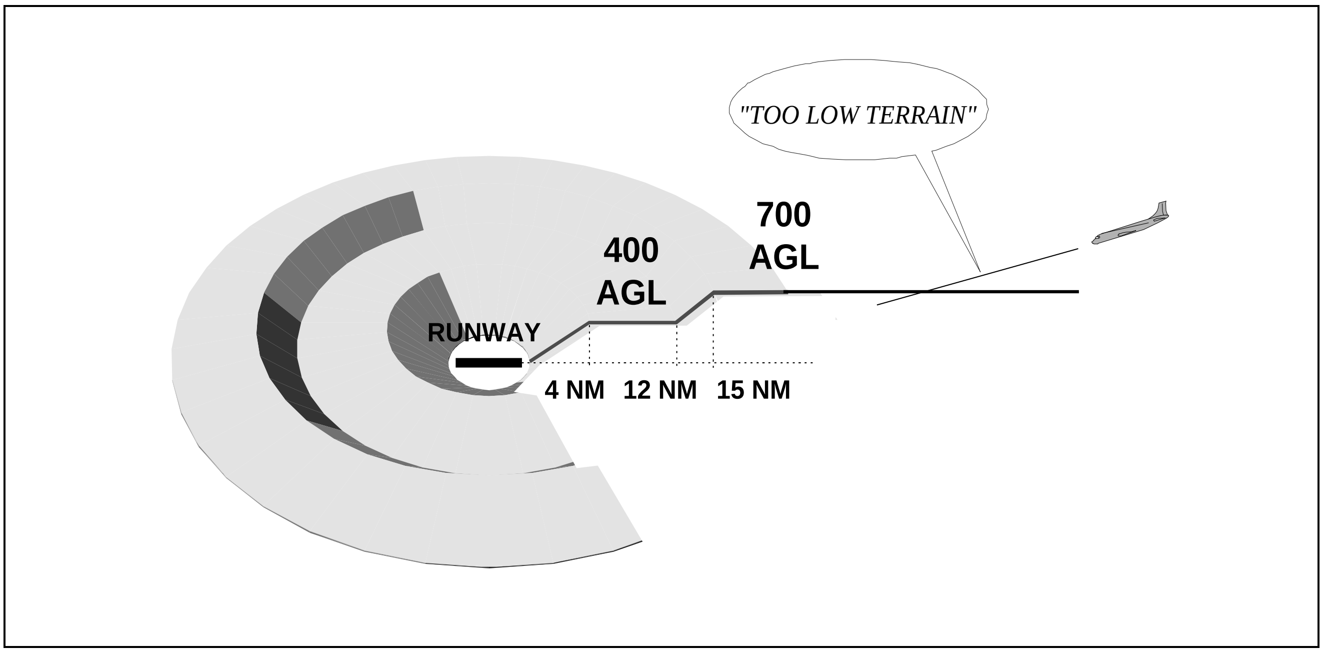


FIGURE 1.3.1.8-1: TERRAIN CLEARANCE FLOOR

1.3.1.9 Mode 7 - Windshear Alerting

Mode 7 produces optional alerts for flight into an excessive windshear condition during takeoff or final approach in accordance with TSO-C117a. The windshear caution, or pre-alert as it is sometimes referred to, provides visual, ARINC 429 and optional aural output indications. The windshear warning also produces visual, ARINC 429 and aural output indications.

Windshear detection is active between 10 and 1500 feet AGL during the initial takeoff and final approach phases of flight. Alerts are provided when the level of windshear exceeds predetermined threshold values. The actual windshear value measured represents the vector sum of inertial vs. airmass accelerations along the flight path and perpendicular to the flight path. These shears result from vertical winds and rapidly changing horizontal winds.

Windshear warning alerts are given for decreasing head wind (or increasing tail wind) and severe vertical down drafts. Windshear caution alerts are given for increasing head wind (or decreasing tail wind) and severe up drafts. The windshear microburst phenomenon and windshear caution and warning levels are illustrated in figure 1.2.3-1.

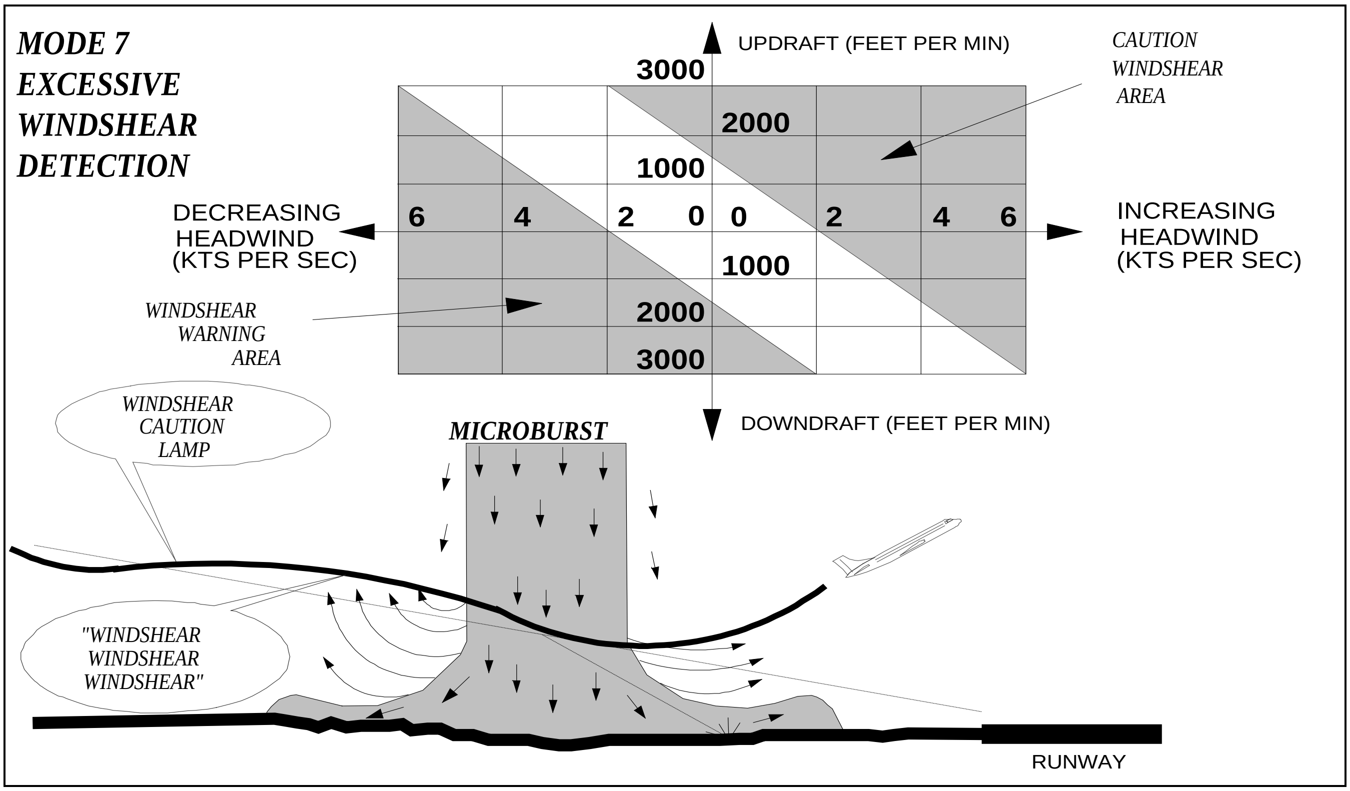


FIGURE 1.3.1.9-1: TYPICAL MICROBURST ENCOUNTER

1.3.2 Terrain and Obstacle Awareness

A major feature of the EGPWS is the Terrain and Obstacle Awareness alerting and display functions. These functions use aircraft geographic position, aircraft altitude and a terrain and obstacle database to predict potential conflicts between the aircraft flight path and the terrain, and to provide graphic displays of the conflicting terrain or obstacle, as illustrated by the block diagram, Figure 1.3.2-1.

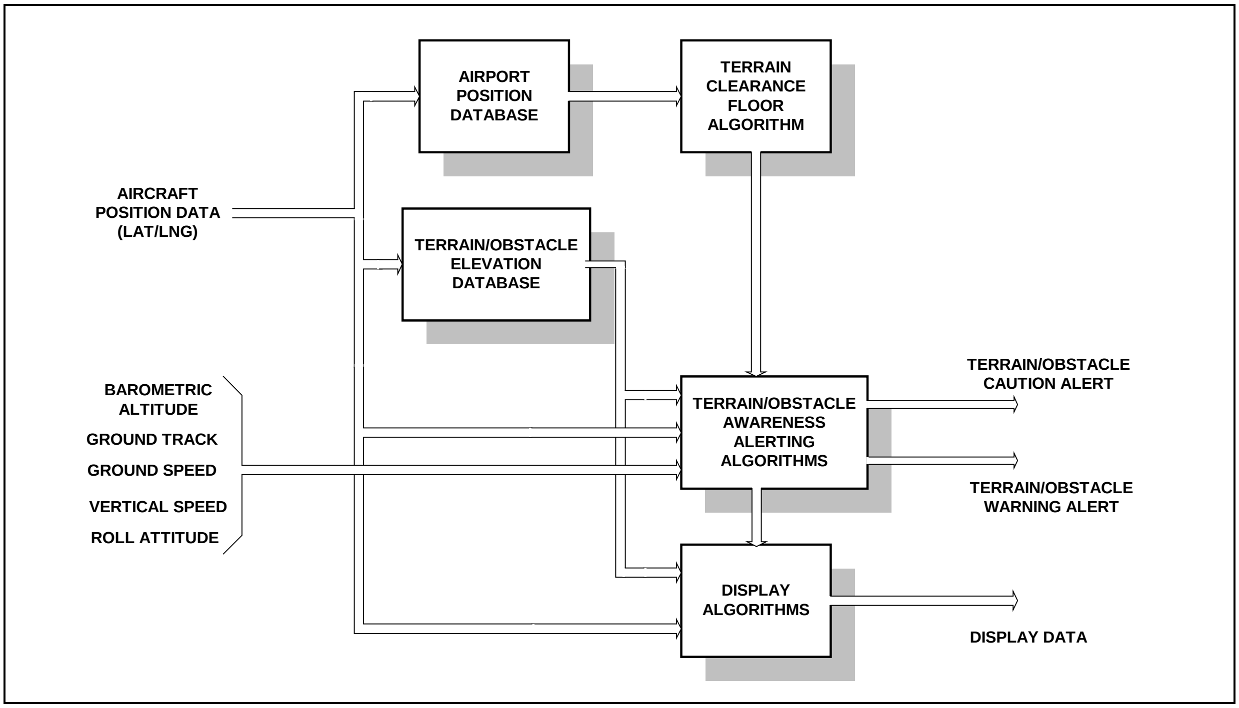


FIGURE 1.3.2-1: TERRAIN & OBSTACLE AWARENESS FUNCTIONS

The MKVIII EGPWS includes a Global Terrain Database, which provides the ability to fly between regions without loss of Terrain Awareness coverage. The MKVI EGPWS includes a Regional Terrain Database, which is one of three regions (see Figure 1.3.2-2,3,4). Use of a MKVI EGPWS outside of the loaded Regional Terrain Database will result in the Terrain Awareness function being unavailable.

The MKVIII EGPWS allows selection between runways greater than 3,500 feet and greater than 2,000 feet. Certain business jet aircraft require longer runways for operation.

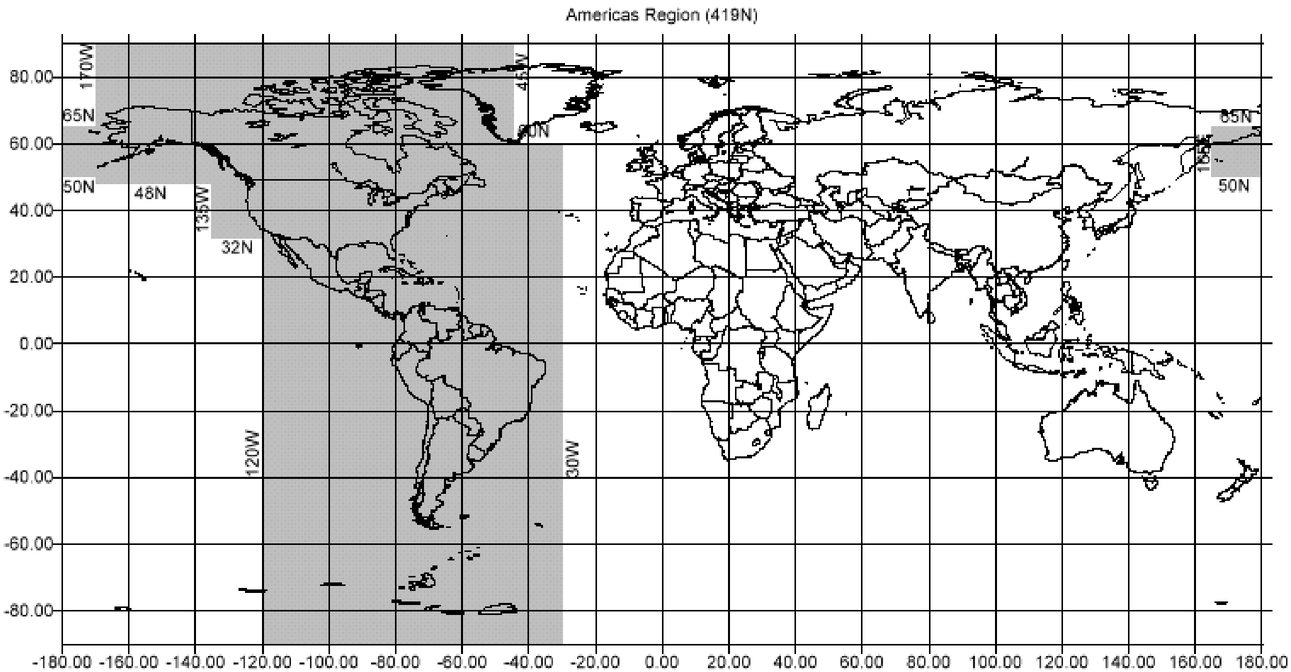


FIGURE 1.3.2-2: TERRAIN DATABASE REGIONS – AMERICAS

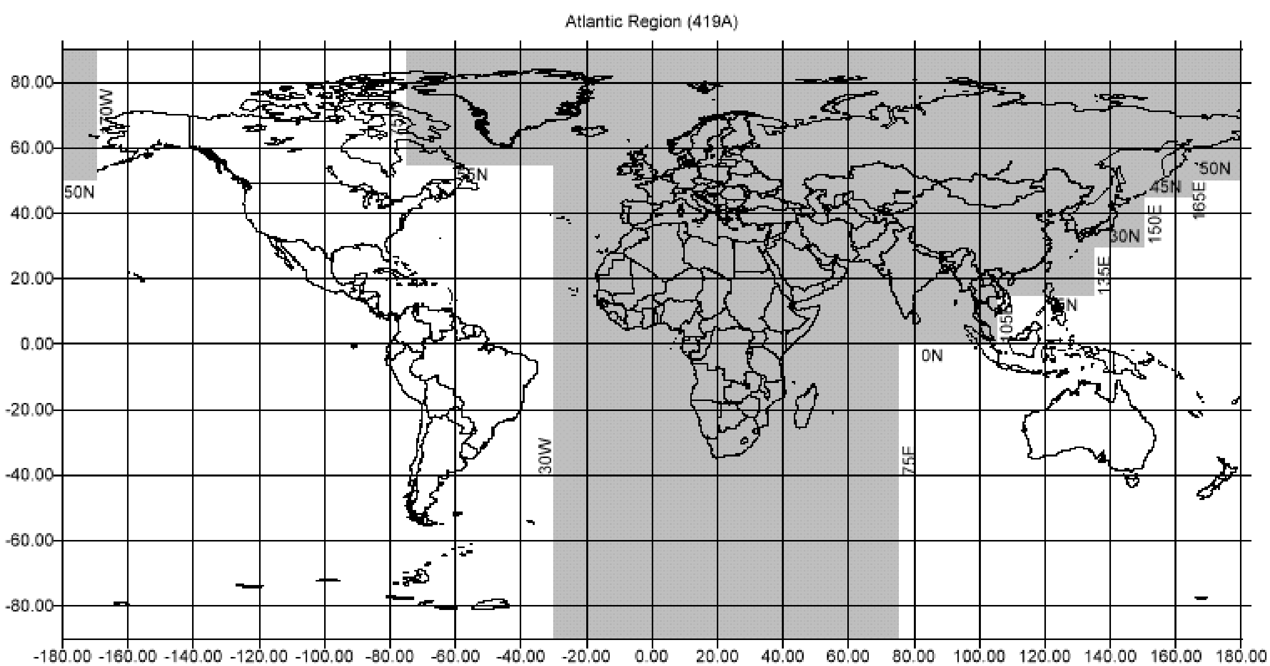


FIGURE 1.3.2-3: TERRAIN DATABASE REGIONS – ATLANTIC

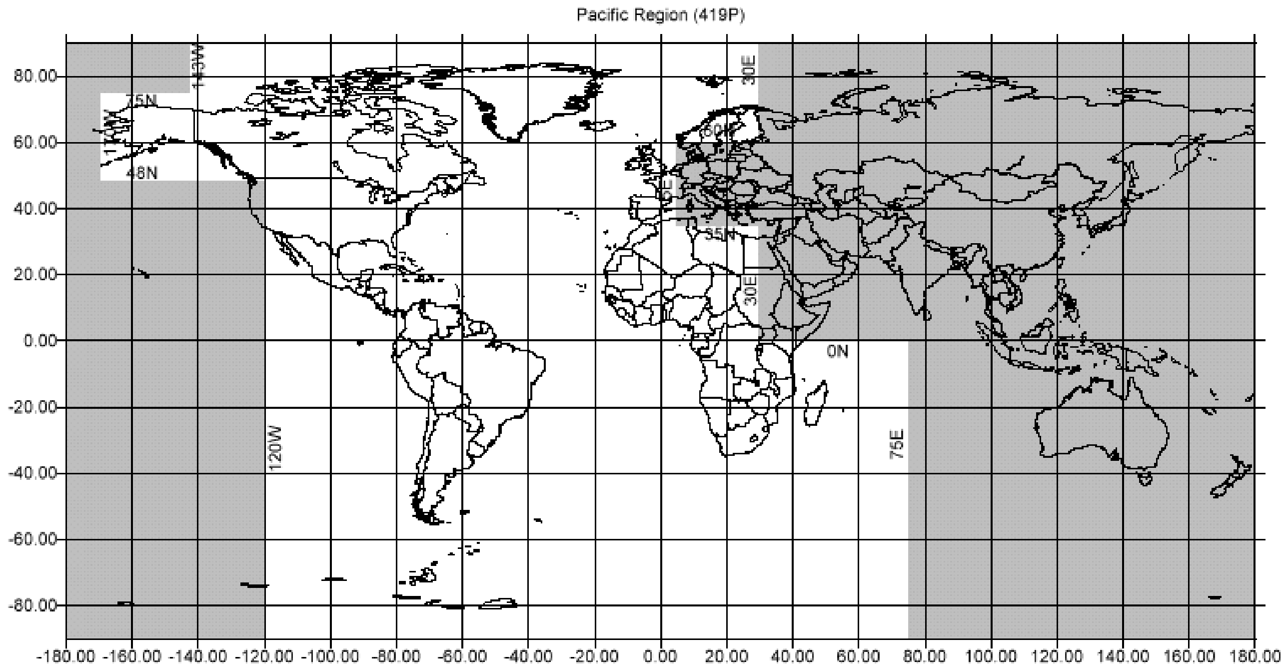


FIGURE 1.3.2-4: TERRAIN DATABASE REGIONS – PACIFIC

1.3.2.1 Terrain Alerting

The Terrain Awareness alerting algorithms continuously compute terrain clearance envelopes ahead of the aircraft. If the boundaries of these envelopes conflict with terrain elevation data in the terrain database, then alerts are issued. Two envelopes are computed, one corresponding to a terrain caution alert level and the other to a terrain warning alert level, as described in section 6.7.3. The algorithms are designed to meet the following criteria:

- Operational compatibility - minimal unwanted alerts during normal flight operations and approach procedures
- Improved Terrain Awareness warning times - provide adequate alert times for all flight phases and conditions
- Robustness - tolerant of aircraft position errors, altitude signal errors and database errors

The caution and warning envelopes use the Terrain Clearance Floor as a baseline, and “look ahead” of the aircraft in a volume which is calculated as a function of airspeed and flight path angle. Simplified diagrams of the terrain caution and warning envelopes are shown in Figures 6.7-2 and 6.7-3 of section 6.7.

If the aircraft penetrates the caution envelope boundary, the aural message *“Caution Terrain, Caution Terrain”* is generated, and alert discretes are provided for activation of visual annunciators. (Note that some installations may use the aural message “Terrain Ahead”). Simultaneously, terrain areas which conflict with the caution criteria are shown in solid yellow color on the terrain display, as described in section 1.3.2.2.

If the aircraft penetrates the warning envelope boundary, the aural message *“Terrain Terrain, Pull Up!”* is generated, and alert discretes are provided for activation of visual annunciators. (Note that some installations may use the aural message “Terrain Ahead, Pull Up”). Simultaneously, terrain areas which conflict with the warning criteria are shown in solid red color on the terrain display, as described in section 1.3.2.2.

1.3.2.2 Terrain Display

The MKVI/MKVIII EGPWC outputs a display of terrain data in KC Picture Bus (KCPB) or weather radar format per ARINC-708/708A (ARINC 453). The terrain data can be displayed either on a shared weather radar indicator or, if the aircraft is equipped with a Display Switching Unit (DSU), on a Honeywell UDI compatible display. If a weather radar indicator is used, when the terrain display is present it replaces the Weather Radar display. The terrain display can be made available to the flight crew at any time. When the conditions for either a terrain caution or a terrain warning are detected, the

MKVI/MKVIII EGPWC supplies a discrete pop-up signal. This can be used to switch flight deck displays between the Weather Radar and the terrain display. In addition, the MKVIII EGPWC can be display terrain on an Electronic Flight Instrument System (EFIS) display.

Terrain is depicted on a display as shown in Figure 1.3.2-5.

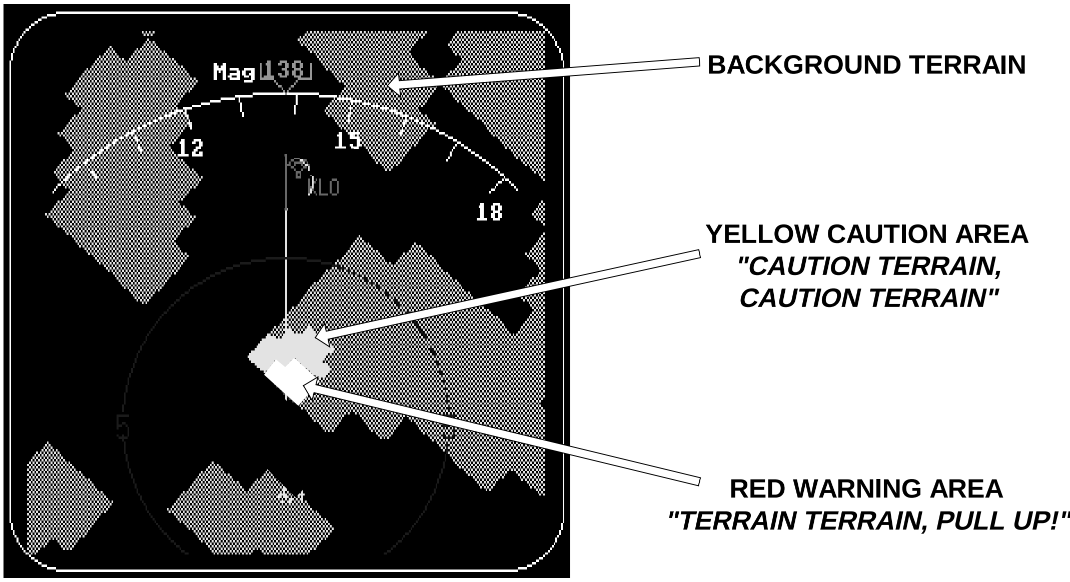


FIGURE 1.3.2-5: TERRAIN AWARENESS DISPLAY ON EFIS NAVIGATION DISPLAY (SIMULATED)

Areas of terrain that satisfy the terrain caution alert criteria are shown in solid yellow, and areas of terrain that satisfy the terrain warning alert criteria are shown in solid red. Terrain which is significantly close to the aircraft, but which satisfies neither the caution or warning criteria, is shown as a green, yellow or red dot pattern whose perceived brightness is less than the yellow caution or red warning area. The density of the pattern is coarsely varied to depict terrain altitude with respect to the aircraft.

Reference section 6.7.4 for a detailed description of the display presentation.

1.3.2.3 Obstacle Alerting

The EGPWS has the capability to detect and annunciate obstacle alerts for obstacles contained in the EGPWS obstacles database. The same visual annunciations that are activated for terrain caution/warning alerts are activated for obstacle caution/warning alerts. The actual alert voices for obstacles are controlled via the selected audio menu. The obstacle voice is similar to the terrain alert, except that for an obstacle alert, the word “Obstacle” replaces the word “terrain”. Obstacle alerting is activated by a configuration item in the configuration module.

1.3.3 Reserved

1.3.4 Maintenance/Test Interfaces

In addition to power-up and continuous BIT, user activated tests (via a discrete test switch), and/or maintenance system commands are supported.

1.3.4.1 Cockpit Self Test

A cockpit mounted test switch is used to manually initiate tests and BIT annunciation anytime the aircraft is on ground. In addition, if the aircraft is above 2000 feet AGL the cockpit self test can be initiated if no alert is in progress.

Notice that there is no test switch located on the EGPWC.

Six levels of information are available through voice messages by pressing the self-test switch. The test sequences can be summarized as follows.

Level 1, Go/No Go Test: This sequence indicates the systems ability to perform all of its configured functions.

For this sequence, when the test switch is activated, the cockpit lamps are activated and voices are issued to indicate what functions are correctly operating. For instance, if no faults exist on an installation that uses the Terrain Awareness function in addition to basic GPWS and windshear, then the result of the self-test would typically be:

“Glideslope---- Pull Up--- Windshear Windshear Windshear----Terrain Terrain, Pull Up”

However, if no valid glideslope input was present then the sequence would be

“Glideslope INOP----- Pull Up--- Windshear Windshear Windshear----Terrain Terrain, Pull Up”

For installations that use a terrain display the interface with the display will be tested by viewing a terrain test image on the appropriate cockpit display. During system self test all INOP type annunciators are activated.

Level 2, Current Faults: This sequence annunciates all faults, if any, that currently exist. It will distinguish between internal and external faults. If no faults exist then the message, “No Faults” is given.

Level 3, Configuration Information: This sequence indicates the versions of the resident hardware, software and databases versions. Also provided are the current configuration item selections from the configuration module, including voice and callout menus selected.

Level 4, Fault History: This sequence annunciates all system faults that were logged for the past ten flight legs. (Information on the last 64 legs is accessible via the RS-232 interface).

Level 5, Warning History: This sequence annunciates all EGPWS alerts that were logged for the past ten flight legs. (Information on the last 64 legs is accessible via the RS-232 interface).

Level 6, Discrete Input Test: This sequence annunciates discrete input transitions to aid system installation and maintenance.

Reference section 6.10.6 for detailed description of self-test functionality.

1.3.4.2 Front Panel Test Interface

The MKVI/MKVIII EGPWC provides a front panel test connector which can be connected to a VT 101 (Terminal Emulation Device) or a portable PC to both receive and control internal data. This test interface can be used for engineering and production testing, both on the bench and at the aircraft. The connector also provides an interface for data loading purposes to a PCMCIA card via a Smart Cable (see section 1.3.5.2.1).

The LRU front panel also contains several fault LEDs. The status LEDs include external fault, computer OK, and computer fail.

Reference section 6.10.4 for more detail.

1.3.5 System Elements
1.3.5.1 Architecture

Figure 1.3.5.1-1 provides a typical block diagram of MKVI EGPWS inputs, Figure 1.3.5.1-2 for outputs. When used, the terrain display output is provided either directly to the DSU, or to display switching relays. The mode curves below are typical, other outputs are possible via configurable mode curves.

The following table summarizes the type and quantity of I/O available with both versions of the EGPWC.

Input/Output Type **Note: Applies to 965-1176, 965-1186, 965-1206, 965-1216.**	**Quantity**
ARINC 429 inputs. The inputs can be software programmed for either high or low speed operation.	8
RS-232/RS-422 inputs.	2
RS-422/ARINC 429 inputs.	1
ARINC 429 output channels (MKVIII EGPWS only)	2
ARINC 429 output channels	1
Picture Bus (ARINC 453/708) output channels.	2
RS-232/RS-422 outputs.	2
3 wire AC analog input channels.	5
2 wire DC analog input channels.	7
Ground activated input discretes.	15
+28VDC activated input discretes.	10
+28V DC activated validity input	3
Configuration Module Interface (requires 6 wires)	1
Smart Cable Interface (requires 8 wires)	1
Discrete outputs. Drivers for Lamps.	12
Audio outputs. An 8-ohm speaker output and a 600-ohm interphone. The audio volume levels are software controlled.	2
Front connector RS-232 interface.	1

TABLE 1.3.5.1-1: EGPWC I/O

Front panel status LEDs are also provided for maintenance and fault isolation.

The primary processing is accomplished with a PowerPC™ microprocessor.

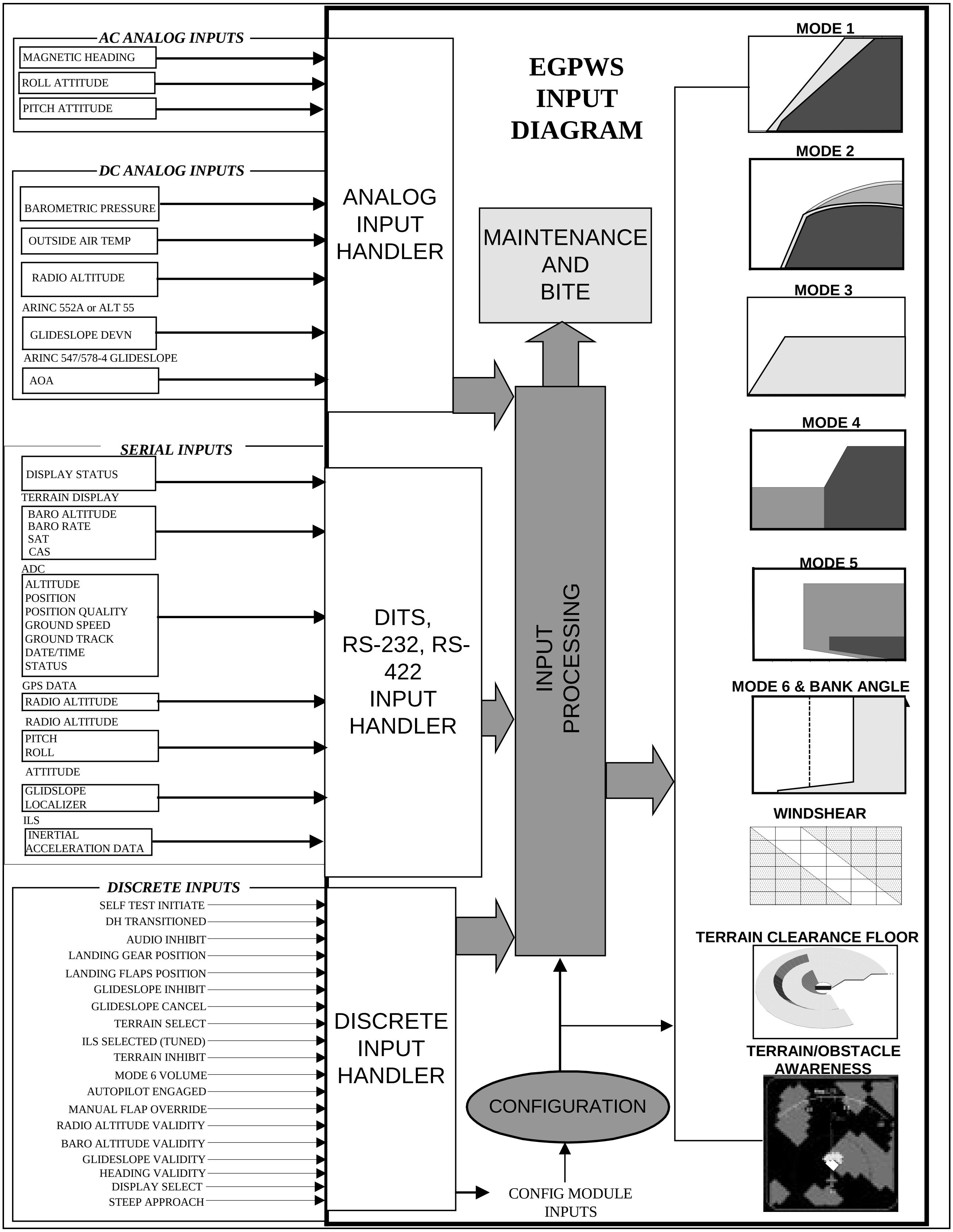


FIGURE 1.3.5.1-1: EGPWS INPUT BLOCK DIAGRAM

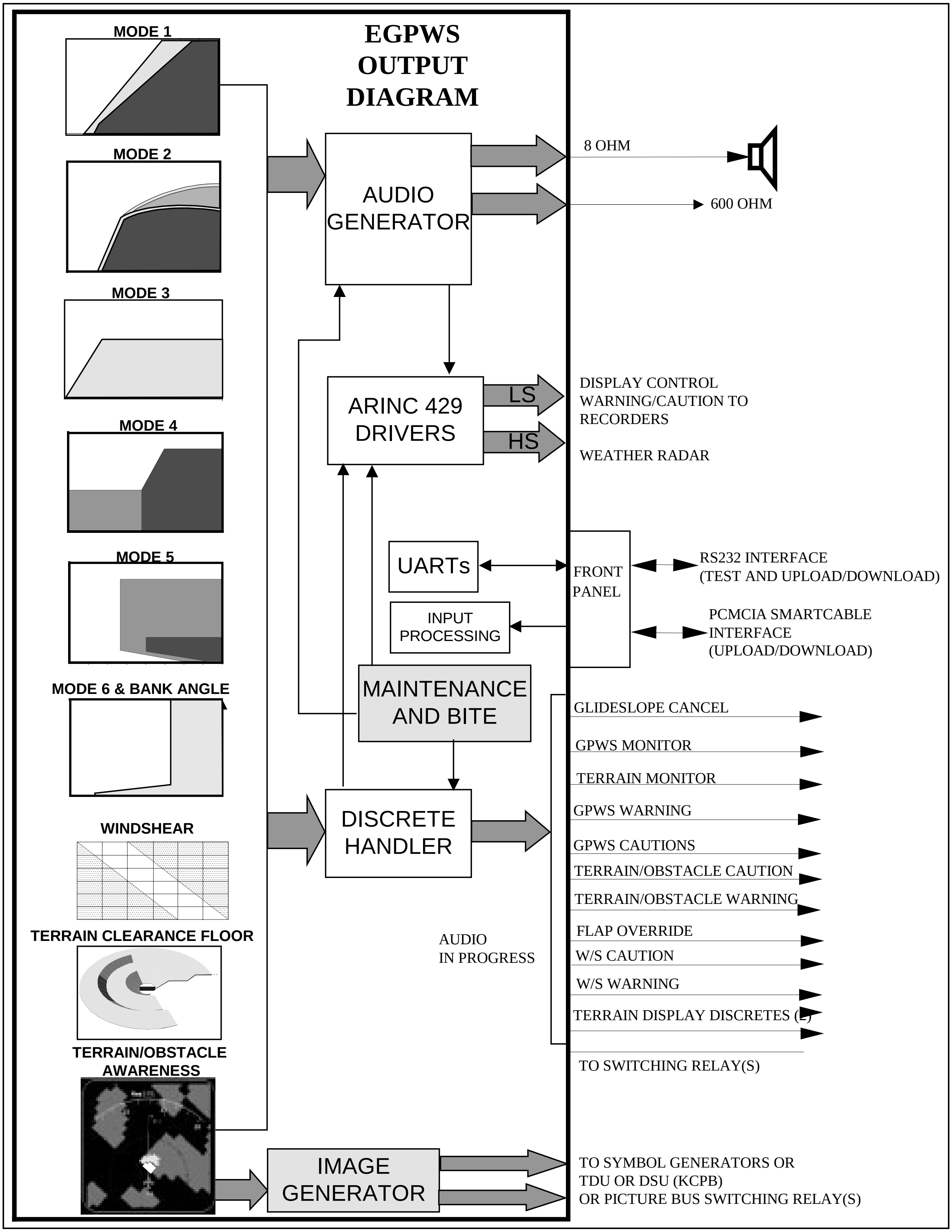


FIGURE 1.3.5.1-2: EGPWS OUTPUT BLOCK DIAGRAM

1.3.5.2 System Components

Refer to section 2.1 for EGPWC outline drawings.

For MKVI EGPWC, 965-1176-xxx or 965-1186-xxx and MKVIII EGPWC, 965-1206-xxx or 965-1216-xxx:

TRAY		
Honeywell P/N	Source/Vendor	Vendor Part Number
405-0383-001	Bendix/King	071-04003-0002

There are two connectors that interface with the Enhanced MKVI/MKVIII computer. The 78 pin and 50 pin front panel interface connectors of the MKVI/MKVIII contain all the interfaces for signals and power. The 78 pin is a Subminiature-D Connector, High Density Series, compatible with connectors conforming to Mil-C-24308.

The 50 pin is a Subminiature-D Connector, compatible with connectors conforming to Mil-C-24308.

P1 78 pin Connector		
Vendor/Supplier	Supplier P/N	Honeywell P/N
Positronics	DD78F10JVLC-15	440-1158-009

P2 50 pin Connector		
Vendor/Supplier	Supplier P/N	Honeywell P/N
Positronics	RD50F10JVLC-15	440-1233-001

One side of the backshell on the 50-pin connector is replaced with the configuration module, which, when installed, is wired directly to the appropriate pins in the connector per the Installation Design Guide.

Configuration Module
Honeywell P/N
700-1701-001

When upgrading from a “classic” MKVI GPWS, the P1 78 pin connector can be re-used if the MKVI/MKVIII EGPWS are non GPS. If the unit is GPS capable then a new P1 connector is required.

The GPS Antenna connector is ONLY required for Enhanced MKVI/MKVIII units with internal GPS receiver.

GPS Connector		
Vendor/Supplier	Supplier P/N	Honeywell P/N
AMP	225554-6	440-1239-001

1.3.5.2.1 System Accessories

In order to dataload the MKVI and MKVIII EGPWS it is necessary to use a Smart Cable which connects to the front panel test connector.

Smart Cable
Honeywell P/N
951-0386-001

1.3.5.3 Databases

The EGPWS contains the following types of databases, which can be loaded via the EGPWC front panel PCMCIA interface independent of the system software. Updates to each database will be made available.

Envelope Modulation Database (see section 6.8)

Terrain Database (see section 6.7.5), which also contains the Runway Database (see section 6.3.1.2) and may also contain an Obstacle Database (see section 6.7.6).

1.3.6 System Limitations

The performance of the EGPWS terrain protection is limited for areas where terrain data is not available, or where navigational accuracy is degraded. Terrain data or runway location data may have errors inherent in the source of such data. Such errors can delay a terrain alert, or may cause unwanted alerts. Such errors do not affect the basic GPWS functions.

The terrain display is to be used to enhance situational awareness only, and is not to be used for navigation or escape guidance.

The basic GPWS function relies on the downward-looking radio altimeter and cannot sense forward terrain. Therefore warning times for flight into precipitous terrain with little or no preamble terrain can be very short. An alert may not be provided for stabilized flight in full landing configuration into a place where there is no runway, and where neither Mode 6 nor the Terrain Clearance Floor function nor the Terrain Awareness function has been enabled.

Terrain clearances or descent rates during radar vectoring that are not compatible with those required by the GPWS Minimum Operating Performance Standards (TSO-C92c, TSO-C151a and CAA Spec 14) may cause unwanted alerts.

1.3.7 Installation Procedures and Limitations

The technical data shall be sufficient to ensure that the article, when installed in accordance with the installation procedures, continues to meet the requirements of the TSO. The limitations shall also be sufficient to identify any unique aspects of the installation. The limitations shall include at least the following:

> "The TSO identifies the minimum performance standards, tests, and other conditions applicable for issuance of design and production approval of the article. The TSO does not specifically identify acceptable conditions for installation of the article. The TSO applicant is responsible for documenting all limitations and conditions suitable for installation of the article. An applicant requesting approval for installation of the article within a specific type or class of product is responsible for determining environmental and functional compatibility."

2 Reference Documents

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial Release and entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General Document Cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
11-JUN-01 – P. Bateman	SCR 6170: General Document Cleanup.	-008	-008
02-JUL-01 – S. Wright	Added review comments	-008	-008

2.0 Introduction

The documents listed in this section shall guide the planning, design and development, implementation and deployment of the MKVI and MKVIII Enhanced Ground Proximity Warning System (EGPWS).

2.1 Honeywell Documents and Drawings

The latest issue of the following documents are applicable to this system.

993-1176-601	Product Description for the MKVI EGPWC
965-1176	System, Enhanced Ground Prox. Warning Computer (MKVI EGPWC)
965-1176-201	Outline, Enhanced Ground Proximity Warning (MKVI EGPWC)
965-1186	System, Enhanced Ground Prox. Warning Computer (MKVI EGPWC with GPS)
965-1186-201	Outline, Enhanced Ground Proximity Warning (MKVI EGPWC with GPS)
965-1206	System, Enhanced Ground Prox. Warning Computer (MKVIII EGPWC)
965-1206-201	Outline, Enhanced Ground Proximity Warning (MKVIII EGPWC)
965-1216	System, Enhanced Ground Prox. Warning Computer (MKVIII EGPWC with GPS)
965-1216-201	Outline, Enhanced Ground Proximity Warning (MKVIII EGPWC with GPS)
060-4314-125	Installation Design Guide for the EGPWS (MKVI/MKVIII EGPWS)
076-0910-001	Acceptance Test Procedure, EGPWC
993-0976-306	System Requirements Document (SRD) for the EGPWC
070-4610-000	Failure Modes Effects and Criticality Analysis For the Enhanced Mark VI/VIII EGPWC w/wo GPS
992-1176-1xx	Software Development Plan
995-1176-6xx	Software Design Requirements Document (SDRD)
992-1176-0xx	Plan for Software Aspects of Certification for the EGPWS
992-0109-1xx	Database Development Process for the EGPWS
995-0109-0xx	Database Requirements & Design Document for the EGPWS
060-4267-000	EGPWS Terrain Database Airport Coverage List
060-4316-000	PCMCIA Card Loading Procedure for the MKVI and MKVIII EGPWC

2.2 Industry and Government Documents

The exact issue of the following documents form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification is considered a superseding requirement. The versions shown below are accurate, references to these documents within the text omit the revision or version defining suffix wherever possible. Where the revision or version is not stated below the latest revision or version as of 8/1/94 shall be utilized.

ARINC 723-1	Ground Proximity Warning System
RTCA DO-161A	Minimum Performance Standards, Airborne Ground Proximity Warning System 27 may 1976
TSO-C92c	Ground Proximity Warning/Glideslope Deviation Alerting Equipment: Technical Standards Authorization, Part 37.201
CAA Spec 14	Ground Proximity Warning System
TSO-C151a	Terrain Awareness and Warning System
EUROCAE Working Group 44	Ground Collision Avoidance System
ICAO Annex 6, Part I and Part II	Ground Proximity Warning System

ARINC 600-8	Air Transport Avionics Equipment Interfaces, 1 April 1991
ARINC 414	General Guidance for Equipment Installation Designers, 3 September 1968
ARINC 429-13	Mark 33 Digital Information Transfer System, 21 February 1992
ARINC 601	Control/Display Interfaces, 10 February 1981
ARINC 604-1	Guidance for Design and Use of Built-In Test Equipment, 31 October 1988
ARINC 609	Design Guidance for Aircraft Electrical Power Systems, 5 January 1987
ARINC 624	Design Guidance for Onboard Maintenance Systems, 26 August 1991
ARINC 424-11	Navigation System Data Base
ARINC 702-5	Flight Management Computer System
ARINC 707-5	Radio Altimeter
ARINC 710-8	Airborne ILS Receiver
ARINC 727-1	Airborne Microwave Landing System
ARINC 706-3	Subsonic Air Data System
ARINC 704-2	Inertial Reference System
ARINC 738	Air Data and Inertial reference System
ARINC 708-6	Airborne Weather Radar
ARINC 708-A	Airborne Weather Radar With Forward Looking Windshear Capability
ARINC 453	Physical, Electrical and Signal Characteristics of Display Data Bus
EIA 232D	Interface Between data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Exchange, January 1987
PCMICA V2.01	PCMCIA Cartridge Standard, November 1992
PCMICA/ ATA V1.01	PCMICA AT Attachment Cartridge Standard, November 1992
PCMCIA/RE V1.00	PCMCIA Recommended Extensions, November 1992
RTCA/EUROCAE	Environmental Conditions and Test Procedures for Airborne DO-160C-3/ED14C-3 Equipment, 4 December 1989.
RTCA/EUROCAE	Software Considerations in Airborne Systems and Equipment DO-178B/ED-12B Certification, 1 December 1992
RTCA /DO -200	Preparation, Verification, Distribution of User Selectable Navigation Data Bases
RTCA/DO-201	User Recommendations for Aeronautical Information Services
RTCA/DO-208	Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS)
C72-4711-01MD-11	Centralized Fault Display System, Operational Description
C72-4711-02MD-11	Centralized Fault Display System, Detailed System Specification
MIL-STD-1629	Failure Mode and Effect Analysis
MIL-STD-785B and Notices	Reliability Program for Systems and Equipment Development and Production, 15 September 1980
MIL-HDBK-217F	Reliability Prediction of Electronic Equipment
MIL-STD-975	Component Stress Analysis
MIL-STD-882	System Safety Program
AC25-12	Advisory Circular - Airworthiness Criteria for the Approval of Airborne Windshear Warning Systems in Transport Category Airplanes
AC25.1309-1A	Advisory Circular - System Design and Analysis
MIL-STD-600006	Vector Product Format (VPF)(For large geographic data bases), April 1992
MIL-STD-600001	Mapping, Charting and Geodesy Accuracy Standard, 26 February 1990
MIL-D-89009	Digital Chart of the World Database, 13 April 1992
MIL-HDBK-850DoD	Glossary of Mapping, Charting and Geodesy(MC&G) Terms
DMA-TR 8350.2	DoD World Geodetic System (WGS) 1984(Its Definition and Relationships with Local Geodetic Systems), 30 September 1987
DMA- TM 8358.1	Datum's, Ellipsoids, Grids and grid Reference Systems
MIL-D-89020	Digital Terrain Elevation Data (DTED)
Data Users Guide	5US GeoData, Digital Elevation Model

2.3 Terrain Data References

A part of the terrain database was processed with approval from the Director General of the Geographical Survey Institute of the Ministry of Construction in Japan (GSI-MC), using the 50-Meter Grid Digital Elevation Model released by the GSI-MC. Approval No: (承認番号　平１０総使、第１６４号)

3 Computer Design Criteria

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial release and entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General Document Cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003

3.0 Introduction

The EGPWS hardware and software are designed to fulfill specific criteria in the areas of resource utilization (via functional partitioning), environmental conditions, reliability and safety, power utilization and reaction to power interrupts, operational performance, mechanical standards, and software design. These criteria are described in detail in the following subsections.

3.1 Functional Partitioning

Partitioning EGPWS resources involves controlling access to system resources in such a way that one partition can not impact the ability of another partition to complete it's assignment. Thus if one function is locked up it will not impact the operation of another function .

3.2 Environmental

The EGPWC conforms to the categories of RTCA/DO-160D "Environmental Conditions and Test Procedures for Airborne Electronic, Electrical Equipment and Instruments" as identified in the applicable sections below.

3.2.1 Environmental, 965-1176-xxx, 965-1186-xxx, 965-1206-xxx, 965-1216-xxx.

ENVIRONMENTAL CONDITION	CATEGORY	MAX/MIN
TEMPERATURE	F2	
High temperature, Non operating		+85 ^{0}C.
High temperature, operating		+70 ^{0}C.
Low temperature, Non operating		-55 ^{0}C.
Low temperature, operating		-55 ^{0}C.
IN-FLIGHT LOSS OF COOLING	Z	No cooling necessary
ALTITUDE	F2	
High altitude		55,000 feet
Decompression	A2	55,000 feet
Overpressure	A2	-15,000 feet
TEMPERATURE VARIATION	B	5^{0}C. per minute
HUMIDITY	A	48 hours at 95% relative humidity, 38-50 ^{0}C, non operating
OPERATIONAL SHOCK AND CRASH SAFETY		
Operational shock	B	normal: 6 G's, 11 msec sawtooth low freq: 6g, 20msec sawtooth
CRASH SAFETY SHOCK		
Impulse shock	B	20 G's, 11msec sawtooth
Sustained shock	B	20 G's
VIBRATION	SMB	Sinusoidal: 0.1"p-p 5-15Hz; 0.01"p-p @ 15-55Hz, decaying to 0.0001"p-p @ 500Hz Random: 1.48grms
EXPLOSION PROOFNESS	E	No test (certification of compliance)
WATERPROOFNESS	X	No test required

Product Specification

FLUID SUSCEPTIBILITY	X	No test required
SAND AND DUST	X	No test required
FUNGUS RESISTANCE	F	No test (non-nutrient material certification) required
SALT SPRAY	X	No test required
MAGNETIC EFFECT	Z	Less than 0.3m
POWER INPUT	A	Normal:22.0-30.3VDC Abnormal: (5 minutes) 20.5-32.3VDC Emergency: 18VDC interrupt for 200msec Normal Surge (30msec): 15-40VDC Abnormal Surge: 100msec @ 46.3VDC, 1 sec @ 37.8VDC
VOLTAGE SPIKES	A	600VDC, 10µs, 50Ω source impedance
AUDIO FREQ. CONDUCTED SUSCEPTIBILITY	Z	0.20Vrms 10-200Hz 0.56 Vrms 200-1,000Hz 1.40Vrms 1,000-15,000Hz 0.20 down to 0.001Vrms, 15kHz – 150KHz
INDUCED SIGNAL SUSCEPTIBILITY	C	Magnetic, unit: 20Arms @ 400Hz Magnetic, cables: 60A-m @ 400Hz down to 1.6A-m @ 15kHz Electric, cables: 5400V-m, 380-420 Hz Induced Spikes: 600V p-p, 2-10µs rate, 3 meters.
RF CONDUCTED SUSCEPTIBILITY	R	10kHz – 500MHz: 0.6mA – 30.0 mA 500kHz – 400 MHz: 30.0 mA
RF RADIATED SUSCEPTIBILITY	R	20 V/m, 0.1 – 0.4 GHz, SW & CW 150 V/m, 0.4 – 8 GHz, Pulse.
RF CONDUCTED EMISSIONS	M	Power: 53 – 20 dBµA @ 0.15 – 2MHz, 20 dBµA @ >2MHz Cables: 73 – 40 dBµA @ 0.15 – 2MHz, 40 dBµA @ >2MHz
RF RADIATED EMISSIONS	M	Complex curves with notches (see DO160D)
LIGHTNING INDUCED TRANSIENT SUSCEPTIBILITY	A3E3	Pin: 600V/24A, 300V/60A Cable: 300V/600A, 600V/120A
LIGHTNING DIRECT EFFECTS	X	No test required
ICING	X	No test required
ELECTROSTATIC DISCHARGE TEST	A	15,000 Volts

3.3 Reliability/Maintainability

3.3.1 Scheduled Maintenance

No scheduled maintenance is required for the EGPWC.

3.3.2 Reliability

A MKVI/MKVIII EGPWC Failure Modes, Effects and Criticality Analysis (FMECA) has been performed and is contained in Honeywell document 070-4610-000. Included in FMECA are MKVI/MKVIII EGPWC assembly level reliability predictions.

Historical MK V EGPWC reliability data and the EGPWC reliability prediction results were used as baseline criteria in establishing the following minimum EGPWC MTBF and MTBUR values.

MTBF for confirmed failures will be 12,500 operating hours or better, for the latest MK VI or MK VIII EGPWS configuration without GPS three years from initial production delivery. MTBF for confirmed failures will be 11,000 operating hours or better, for the latest MK VI or MK VIII EGPWS configuration with GPS three years from initial production delivery.

MTBUR will be 9,000 operating hours or better, for the latest MK VI or MK VIII EGPWS configuration without GPS three years from initial production delivery. MTBUR will be 8,000 operating hours or better, for the latest MK VI or MK VIII EGPWS configuration with GPS three years from initial production delivery.

The MKVI and MKVIII EGPWS MTBUR goals presume proper line troubleshooting procedures are followed when diagnosing system failures.

The MKV EGPWC FMECA is contained in Honeywell document 070-4507.
The MKVI/MKVIII EGPWC FMECA is contained in Honeywell document 070-4610-000
The MKV EGPWC reliability prediction is contained in Honeywell document 070-4521.
The MKVI/MKVIII EGPWC reliability prediction is contained in the MKVI/MKVIII EGPWC FMECA.

3.4 Performance

The EGPWC operational performance will meet as a minimum the requirements of TSO-C92c, TSO-C151a and CAA Specification 14. The actual performance is defined in the EGPWC Systems Requirement Document (SRD).

3.5 Power

3.5.1 EGPWC Power Requirements

The maximum input power to the MKVI/MKVIII EGPWC is 28 watts under all operating conditions except when heater blanket is on (including audio output). Refer to Appendix C for power pin designations.

End Item Part Number	965-1176-xxx 965-1186-xxx with internal GPS 965-1206-xxx 965-1216-xxx with internal GPS
EGPWC Input Power Type	28 VDC
EGPWC Inrush Current	@18V DC 3 Amps for 197ms @28V DC 3 Amps for 307ms
EGPWC Input Power Requirement With No Warning:	9 Watts
With Warning (over 8 Ω speaker):	16 Watts
With GPS Card Option [1]:	Add 3 Watts
With Heater Blanket On [2]:	Add 49 Watts (typical)
Recommended EGPWC Power Control Device	3 Amp Delayed Action Circuit Breaker

[1] Based on the Honeywell GPS Xpress card specification

[2] The heater blanket turns on at temperatures ≤ -23^{0}C and turns off at temperatures ≥ -20^{0}C

3.5.2 System Response to Power Interrupts

On application of power to the EGPWC, the computer will perform a power up BIT test to assure proper system performance prior to initiation of normal operation. The time delays before commencing normal operation will be as defined in the tables below. The EGPWC system response to power interrupts will be as follows:

Power interrupt duration	System Response	Maximum Delay to Normal Operation
T < 200 msec.	No effect	Not applicable
T ≥ 200 msec.	Cold start	20 seconds Max

3.6 Mechanical

3.6.1 Packaging

The MKVI and MKVIII EGPWC are packaged in a similar form factor chassis to the MKVI GPWS except with an additional 50 pin front panel interface connector, an additional 15 pin front panel test connector, an additional TNC connector for the GPS antenna interface and new status LEDs. The outline length and width are the same but the height is 0.2” taller, this allows the existing mounting interface to be used. The part number appearing on the front panel identification plate for the MKVI EGPWS (w/o internal GPS) is 965-1176-0xx. For the MK VI with Internal GPS this is 965-1186-0xx which identifies the hardware part number and application software version. (MKVIII without and with Internal GPS are 965-1206-0xx and 965-1216-0xx respectively). Additionally the installed database is identified on the front panel.

3.6.2 Connectors

3.6.2.1 MKVI/MKVIII EGPWC, 965-1176-xxx/965-1206-xxx Front Connector

The main front connectors for the 965-1176-xxx MKVI EGPWC and 965-1206-xxx MKVIII EGPWC are listed in section 1.3.5.2. Refer to the Installation Design Guide for pin-out information.

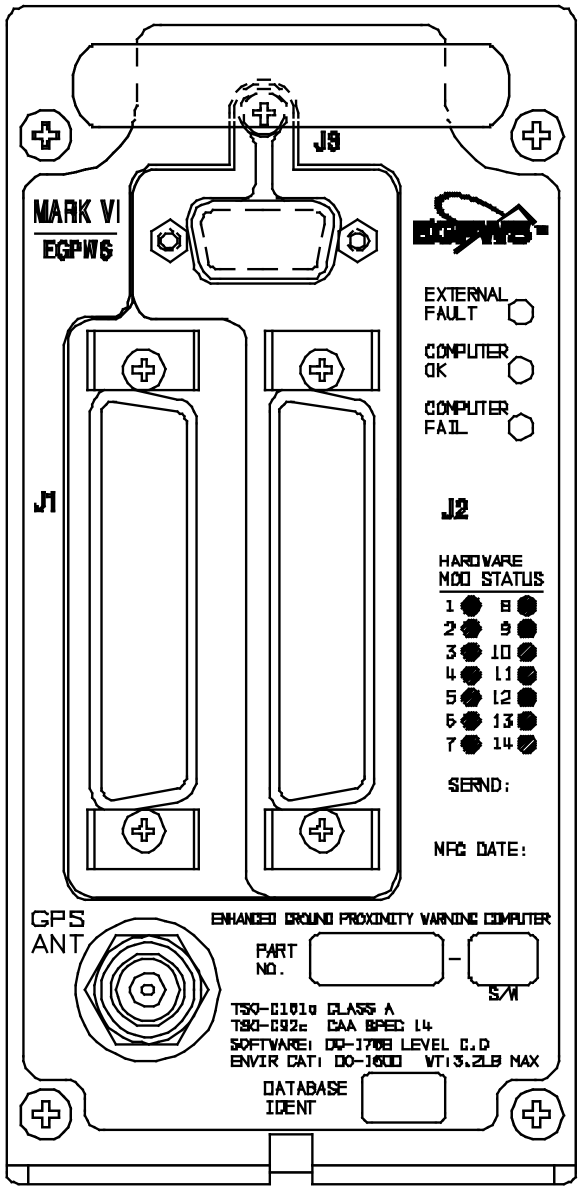


FIGURE 3.6.2.1-1: FRONT CONNECTORS FOR THE MKVI/MKVIII EGPWC (MKVI SHOWN)

The configuration module is listed in section 1.3.5.2 and is installed on the connector as shown in Figure 3.6.2.1-2.

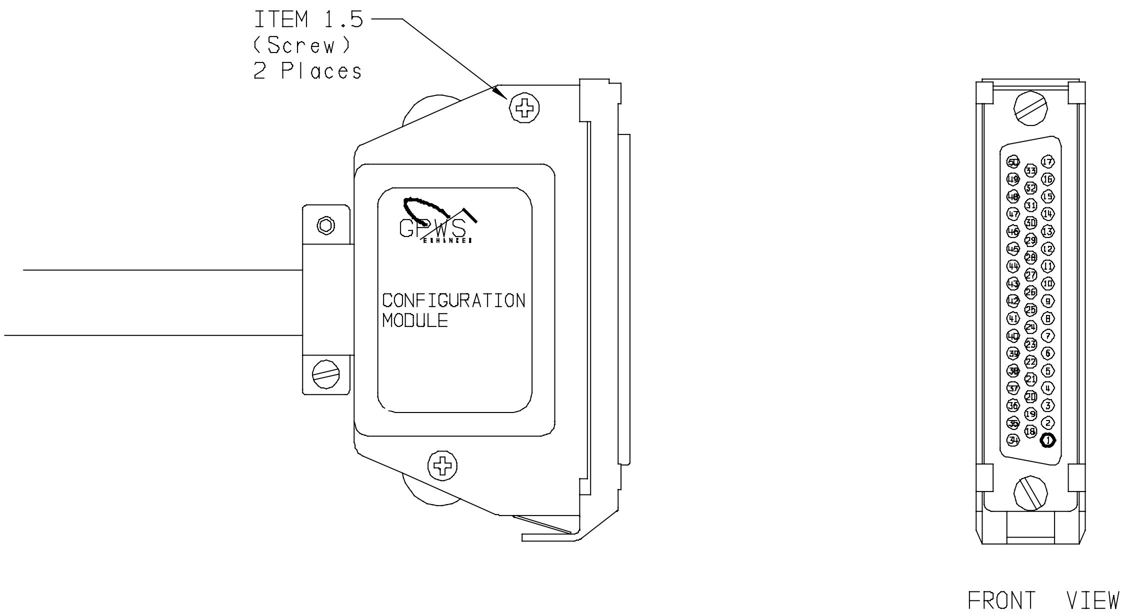


FIGURE 3.6.2.1-2: CONFIGURATION MODULE (SHOWN AS INSTALLED)

3.6.2.2 Front Panel Test Connector

A test connector is provided on the EGPWC front panel. This provides access for a PC test monitor and future portable data loading capabilities. Reference section 6.10.4 for pin-out and functional details. The mating connector for the EGPWC test plug is a male (pins) 15 pin double density D-subminiature type, Positronics Industries (kit) part number ODD15M1OYOZ or the following individual parts:

Nomenclature (AMP)	Amp Part Number	Military Part Number
Connector Shell (HDP-22 Crimp Snap In Contact)	748364-1	reference MIL-C-24308
Size 22 DM Crimp Snap In Contacts Pin ø.030	204370-2	M39029/58-360
Backshell (Shielded Cable Clamp Assembly)	745854-5	
Jackscrews (4-40 Male Jackscrew Kit)	747784-8 (specify quantity of 2 per connector)	
Grommet Sets	747746-1	

The following tools will work with Positronics, Amp, and Mil Spec Connectors:

Insertion / Extraction Tool	91067-1	M81969/1-04
Hand Crimp Tool		M22520/2-01
Positioner		M22520/2-09

3.6.3 Mounting

Vibration isolation or shock mounting is not required.

3.6.4 Cooling

Cooling shall be per ARINC 404A convection cooling. No forced air-cooling is required for specified system performance over the environmental conditions specified in paragraph 3.2 of this document.

3.6.5 Weight

The maximum weight of the 965-1176-xxx MKVI EGPWC is 3.4 pounds.
The maximum weight of the 965-1186-xxx MKVI EGPWC with internal GPS is 3.5 pounds.
The maximum weight of the 965-1206-xxx MKVIII EGPWC is 3.4 pounds.
The maximum weight of the 965-1216-xxx MKVIII EGPWC with internal GPS is 3.5 pounds.

3.7 Software Design Requirements

The EGPWC software development process creates software, which meets the guidelines of RTCA DO-178B, Levels C and D as identified in the following table. Refer to the Software Development Plan for the EGPWC (SDP) for additional information regarding the Computer Software Configuration Items (CSCIs) listed below.

EGPWC SOFTWARE DEVELOPMENT AND CERTIFICATION			
CSCI	Component	Function	Certification
Application Software	Shared Functions	Utilities	DO-178B Level C
		Operating System	DO-178B Level C
		Flash File System	DO-178B Level C
		Current Value Table	DO-178B Level C
		Configuration	DO-178B Level C
		Non-Volatile Memory	DO-178B Level C
	Monitoring Functions	Task Monitor	DO-178B Level C
		Built In Test	DO-178B Level C
	I/O Functions	Input Processing	DO-178B Level C
		Output Processing	DO-178B Level C
	Alerting Functions	Ground Proximity Warning	DO-178B Level C
		Advisories	DO-178B Level C
		Windshear	DO-178B Level C
		Terrain Awareness	DO-178B Level C
	Maintenance Functions	Self Test	DO-178B Level D
		Maintenance System Support	DO-178B Level D
		Flight History	DO-178B Level D
		Keyboard Monitor	DO-178B Level D
Boot Loader Software			DO-178B Level C
DITS Handler Software			DO-178B Level C
Analog Acquisition Software			DO-178B Level C
Configuration Database			DO-178B Level C
Envelope Mod Database		Database B01	DO-178A Level 2
		Database B02 and on	DO-178B Level C
Terrain Database			DO-200A

4 External Interface

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial Release and Entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General Document Cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003

Refer to the Installation Design Guide.

5 Functional Inputs

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial Release and Entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General Document Cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003

Refer to the Installation Design Guide.

6 System Functions

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial Release and entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003

6.0 Mode Control

EGPWC uses mode control to enable specific features in the EGPWC modes. The current flight phase of the aircraft is identified, such as takeoff or approach, and is used to select the modes of the EGPWC. Various flight phases are described in the following sub-sections.

6.0.1 Air/Ground Mode

The system must be able to determine if the aircraft is airborne to control warning modes, maintenance functions, and fault isolation logic. The airborne value is stored and immune to power interruptions to prevent inadvertent change of state during power loss.

When airspeed is greater than 60 knots and radio altitude is greater than 30 feet for more than 1 second, then the system will go ‘In Air’.

The aircraft is considered not airborne (i.e. on ground) when the airspeed drops below 40 knots and the radio altitude becomes less than 30 feet.

6.0.2 GPWS Takeoff/Approach Mode

Takeoff/approach GPWS mode status is used to control portions of Modes 3, 4, 5 and 6. Mode 3 and Mode 4C are only active during the takeoff phase of flight, while Modes 4A and 4B are only active during the cruise and approach phases of flight. Mode 5 is active during the approach mode with gear down and can be active in the takeoff mode with both gear and flaps in landing configuration. Mode 6 utilizes the takeoff to approach mode switching to re-enable callouts.

Approach mode to takeoff mode switching is accomplished when the aircraft passes below the 150 foot Mode 4B floor without a warning (i.e., gear down and flaps in full landing configuration). At this time, the Mode 3/Mode 4C warning logic is activated. The state of this switching function is maintained in nonvolatile memory to avoid inadvertent selection of an improper mode during power loss.

The basic configuration requires that the following algorithms be satisfied before the switch from takeoff to approach mode can occur. For this algorithm, the Mode 4C minimum terrain clearance filter described in section 6.2.4 is used to control the switching from takeoff to approach. After takeoff, the switch to approach mode will normally be enabled when the filter value exceeds 500 feet. This will occur at or above 667 feet radio altitude, depending on the time allowed to charge the filter. In the event that airspeed has increased to greater than 178 knots, the mode switching will be further delayed until the floor reaches the expanded Mode 4A warning boundary. A maximum expansion of 750 feet occurs at airspeeds greater than 200 knots and will result in mode switching being enabled at or above 1000 feet radio altitude.

This is the basic configuration of the MKVI/MKVIII and is an improvement over the original switching algorithm from the MKII.

The MKII uses a fixed radio altitude level to switch modes, with its algorithm it is possible to switch modes prematurely and get a nuisance Mode 4 warning. Two examples will illustrate the problem using a 700-foot radio altitude for mode switching.

In the first MKII example, passing over a river valley, or other large terrain depression during takeoff, may temporarily indicate above 700 feet radio altitude and allow switching to Mode 4. If radio altitude then decreases below 500 feet, a Mode 4 warning will occur.

In the second MKII example, emphasizing a speed increase over climb gradient during takeoff can allow the airspeed to exceed 214 knots before reaching 700 feet radio altitude. Switching to Mode 4 at 700 feet then produces a “Too Low Terrain” warning.

By using both the MKVI/MKVIII algorithm, the previous potential problems are eliminated and the noise abatement procedures can be handled without creating nuisance warnings due to premature takeoff to approach mode switching.

6.0.3 MKVIII EGPWS Windshear Takeoff/Approach Mode

Separate logic is utilized to control the takeoff/approach mode switching for mode 7 windshear detection. The takeoff state actually reflects takeoff or go-around. The approach state reflects final approach. The state of this latch is maintained in nonvolatile memory in order to prevent inadvertent mode switching as a result of power loss.

6.0.4 Mode 2 Takeoff

A Mode 2 Takeoff Latch is provided to enable Mode 2B for the first 60 seconds following a takeoff. This latching function is not power saved and a system reset will force it false.

This feature addresses certain false “TERRAIN” warnings that occur just after takeoff caused by false radio altimeter excursions between 1000 and 1500 ft AGL. These typically are a sharp increase, followed by a sharp decrease in radio altitude. This problem is solved by activating Mode 2B for the first 60 seconds after takeoff. Limiting the Mode 2 closure rate to +3000 fpm effectively prevents the “TERRAIN” warnings in the same manner as is used on approach.

6.0.5 Simulator Reposition

When the EGPWC is installed on an aircraft simulator, special consideration must be taken when the simulation is repositioned for different flight scenarios. The normal logic of the EGPWC assumes actual flight phase transitions; the abrupt repositioning of a simulation can cause false warnings or cause the normal EGPWC logic to “lock up” awaiting a valid transition.

For the MKVI/MKVIII EGPWS the simulator reposition is provided via a keyboard monitor command. When instructed (RS232 command over the J3 (test) connector) the EGPWS will remain in a reposition setup mode for approximately 3 seconds after the command to “normal” has been received.

6.0.6 Terrain Awareness Alerting Guard

Terrain Awareness caution and warning voice alerts, lights and threat display are inhibited below 30 feet of radio altitude within 1 mile of the runway, or below 60 knots groundspeed.

6.1 Configuration Module

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial Release and entry into PVCS.	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003

MKVI/MKVIII application uses a configuration module instead of the program pins used by MKV/MKVII EGPWS. This configuration module contains a minimum of 256 bytes of memory and is capable of transmitting the memory contents to the EGPWC. The definition of the MKVI/MKVIII feature selections can be found in the MKVI/MKVIII EGPWS Installation Design Guide. The definition of the data transfer from the configuration module to the MKVI/MKVIII is defined in section 6.10.15. Section 6.10.15 also covers configuration module validity checking and INOP generation that are covered in this section for the MKVI/MKVIII.

It can be determined if the application is to run as a MKVI or a MKVIII by reading Non-Volatile Memory (NVM).

The configuration module is read by the EGPWS only during power up. The configuration is copied into NVM as long as there is not a configuration module configuration fault or a configuration module unprogrammed fault.

The configuration module is programmable via an RS232 Interface using a keyboard monitor or user interface tool. The contents of the configuration module can also be read back by the user through these interfaces.

6.1.1 MKVI EGPWS Feature Selection

Refer to the Installation Design Guide for details on what configuration items options are available for the MKVI EGPWS.

6.1.2 MKVIII EGPWS Feature Selection

Refer to the Installation Design Guide for details on what configuration item options are available for the MKVIII EGPWS.

6.2 GPWS Functions

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial Release and entry into PVCS	-001	-001
08-MAR-00 M. Calhoun	SCR 4908: Corrected Mode 1 curve in Figure 6.2.1-2. Added Figure 6.2.4.1-2A to correctly show Mode 4A type 5.	-001	-001
24-MAY-00 Susie Wright	SCR 4795: Add Envelope Modulation for EM6/8. General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
01-DEC-00 – Susie Wright	Doc only change - Added Lamp Format 2 plus general document cleanup.	-006	-006
27-FEB-01 – M. Calhoun	SCR 5803: Added addition text to steep approach in 6.2.1.	-008	-008
07-JUL-01 – S. Wright	Added review comments.	-008	-008
30-JAN-02 – N Paterson	Doc only change. Added TAD High Integrity paragraph to mode 4.	-010	-010

GPWS functions consist of Modes 1 through 5 as generally described in section 1.3. Mode outputs consist of the following:

Voice messages via the 8 and 600 ohm audio outputs.
Lamp driver outputs.

In addition, all voice messages, and lamp driver states, are output on ARINC 429 labels for EFIS display flight recording, and test purposes.

6.2.1 Mode 1 -- Excessive Descent Rate

Mode 1 provides an alert based on valid radio altitude and valid aircraft descent rate. The descent rate is computed based on barometric rate from the Air Data Computer (ADC). Two different alert envelopes are possible. Through Envelope Modulation, both envelopes can be biased to the right at certain airports to minimize nuisance alerts. Figure 6.2.1-1 illustrates Mode 1 functionality.

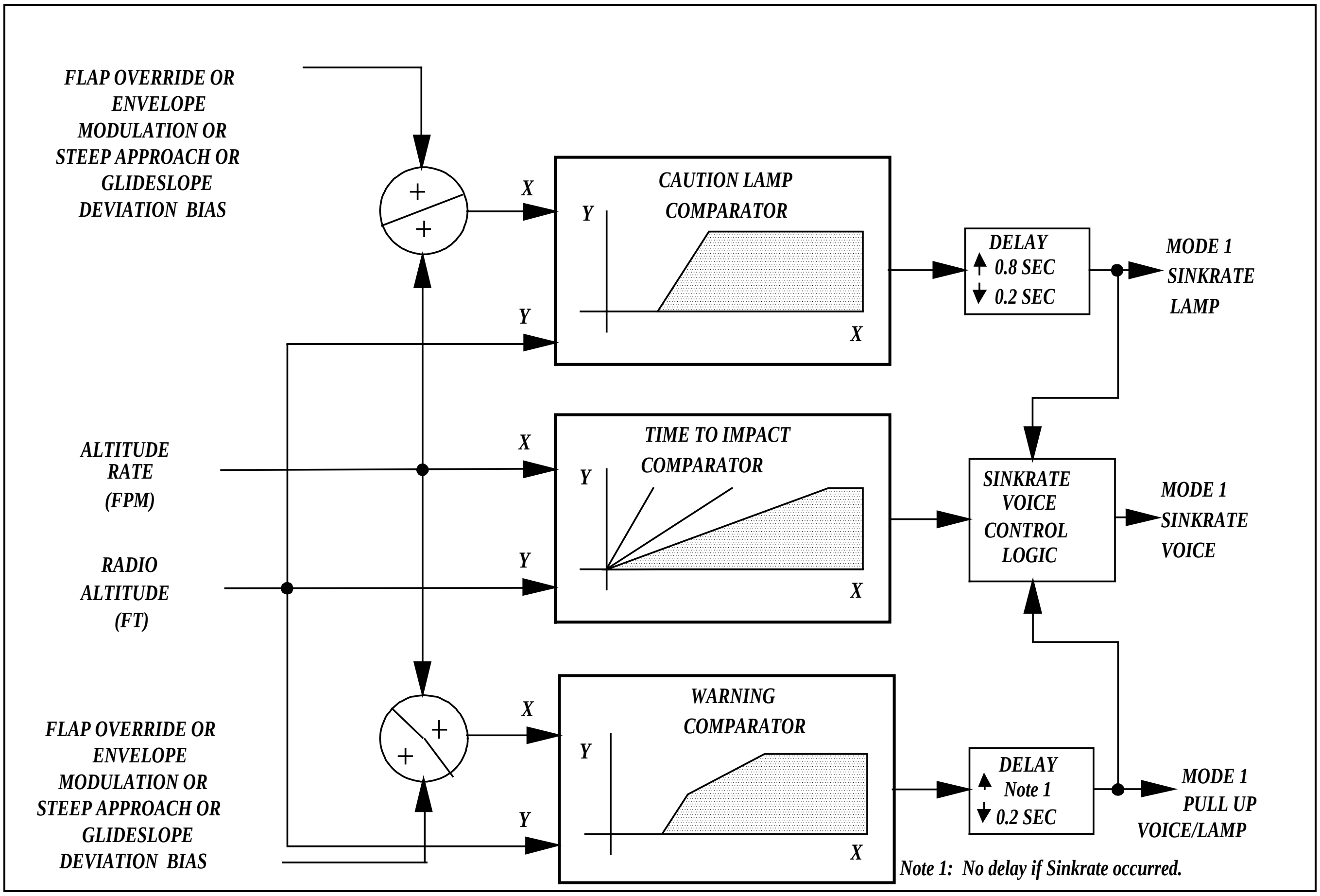


FIGURE 6.2.1-1: MODE 1 BLOCK DIAGRAM

Figure 6.2.1-2 illustrates the static alert envelope for the Mode 1 outer envelope for turboprop airplanes, which is typically the "Sinkrate" warning area. The curve for turbofan airplanes is similar, but it extends down to 10 feet as shown in Figure 6.2.1-2A. This static alert envelope assumes that all signals are generated instantaneously (i.e. no filter lags or time delays), and that the bias terms are zero.

The static Mode 1 outer curve is a straight line with the equation:

RADIO ALTITUDE (FT) = -572 (FT) - 0.6035 * ALTITUDE RATE (FPM)

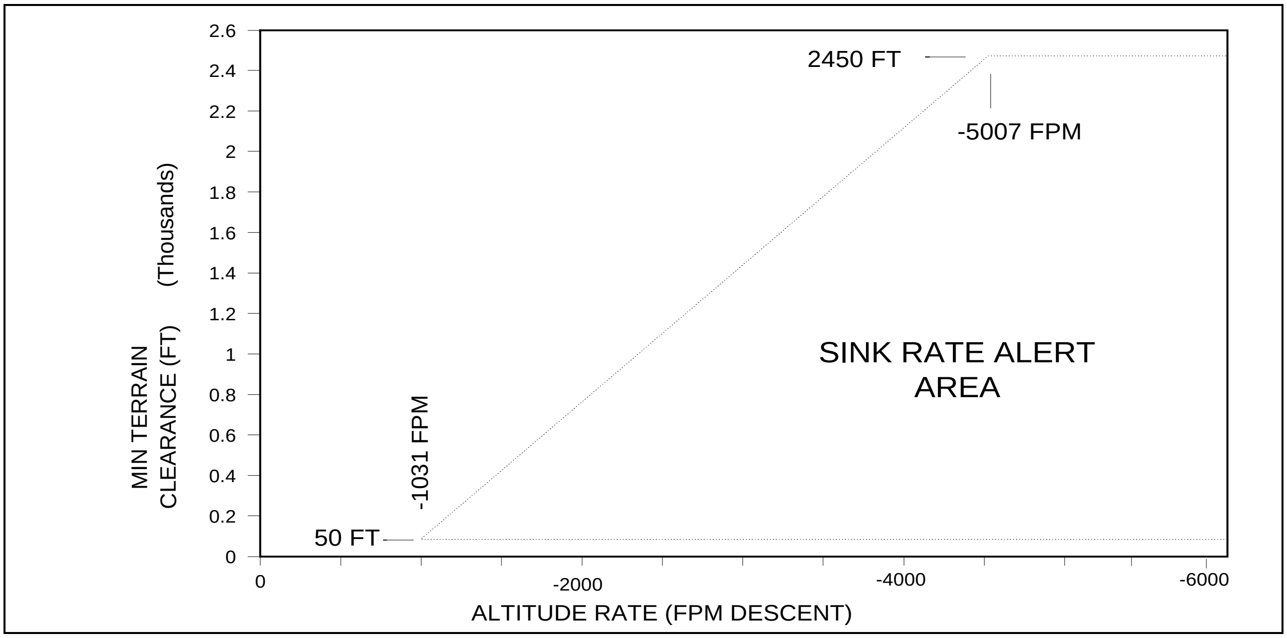


FIGURE 6.2.1-2: MODE 1 OUTER CURVE (TURBOPROP)

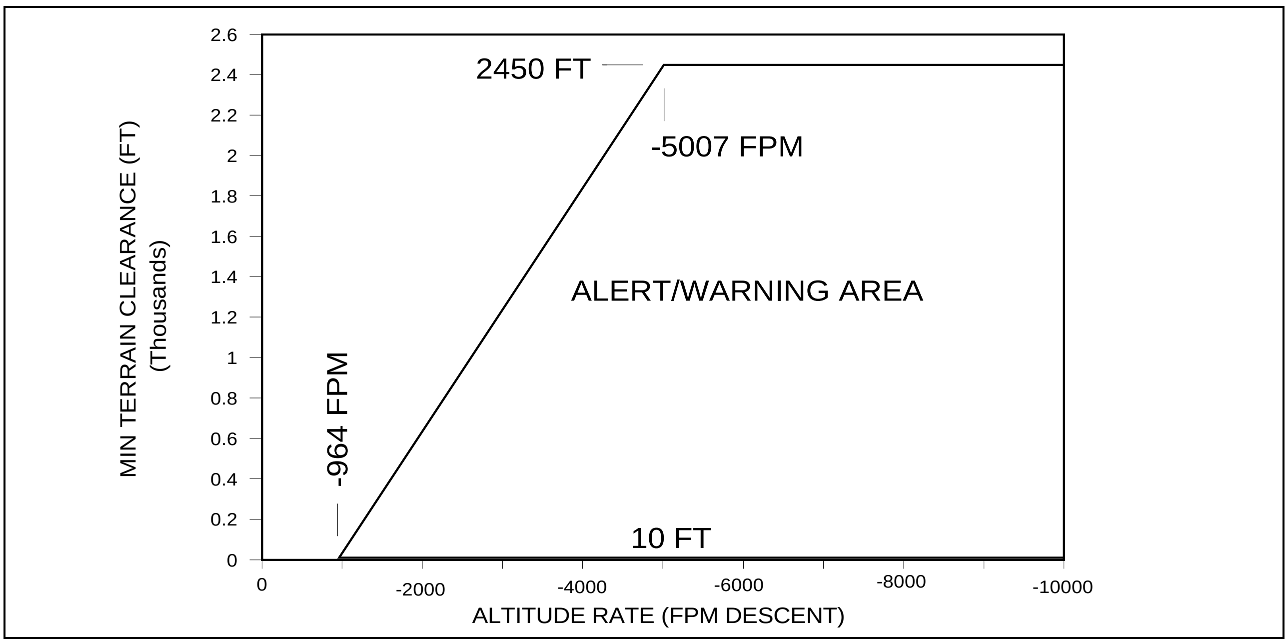


FIGURE 6.2.1-2A: MODE 1 OUTER CURVE (TURBOFAN)

The Mode 1 outer alert boundary is biased to the right as a function of glideslope deviation above (fly down) the beam in order to prevent unwanted alerts while re-positioning from above the beam.

This bias is applied to the outer envelope, which effectively moves the envelope to the right with increasing deviation above the glideslope beam. This term is weighted to provide "0 FPM" of bias when the aircraft is centered on the beam and "300 FPM" of bias when the aircraft is two dots above the beam. The term is also modified close to the ground by the value of radio altitude, varying from zero bias at zero feet altitude up to 100% bias above 100 feet radio altitude. These functions vary linearly between these two limiting values. The bias is not applied to the inner envelope.

A bias is applied to both the outer and inner envelopes in the event that the pilot selects flap override. For turboprop aircraft (MKVI or MKVIII EGPWS), flap override biasing can be enabled by the pilot anywhere above 50 feet terrain clearance, and will be automatically disabled at or below 50 feet during landing. For turbofan aircraft (MKVIII EGPWS only), the same applies, except that the flap override bias will be disabled at 10 feet. If the flap override biasing is in effect, then the envelope modulation biasing and the glideslope deviation biasing shall be disabled. The bias will be 300 FPM to the right.

For some installations a steep approach bias can be optionally applied to the Mode 1 curves. If steep approach is enabled and the steep approach discrete is selected, then fixed positive biases are added to both the Sinkrate curve (500 FPM), and the Pull Up curve (200FPM). If steep approach is activated, then the cockpit self test is inhibited when the aircraft is on the ground. The selected Discrete I/O category ID will provide either an alternate action Steep Approach switch input, or a momentary type switch input. The momentary type provides an automatically resetting Steep Approach function. Pressing the switch once will activate Steep Approach. It can be cancelled by pressing the switch again, or will automatically reset when the aircraft lands, or flaps/gear raised for a go-around. Use of the momentary switch requires that it be illuminated by the Steep Approach Lamp discrete output. This lamp is also activated if Envelope Modulation activates a Steep Approach.

Penetration of the outer envelope will activate the caution lamps (or warning lamps if using Lamp Format 1) and produce the voice message "Sinkrate".

The audio message for penetration of the outer envelope will be repeated twice, then will remain silent unless the excessive descent rate condition degrades by approximately 20%, as determined by the computed time to impact (i.e. radio altitude/altitude rate). If 20% degradation in time to impact is computed, then additional two messages are given and the cycle repeats. This situation will continue until the outer envelope is exited or until the Mode 1 inner envelope is penetrated. It is important to note that using constant time to impact as the condition for holding the voice messages off assures that the flight profile must be correcting toward lower descent rates at lower altitudes AGL. If the profile is not corrected, the voice messages will continue to repeat getting closer and closer together as radio altitude is lost. The Mode 1 caution/warning lamp output remains active so long as the excessive descent rate conditions exists.

During the time that the voice message for the outer envelope is inhibited and the caution/warning lamp is on, the Mode 5 alert message is allowed to annunciate for excessive glideslope deviation conditions. No additional lamps will come on. This provides additional information to the flight crew in that not only are they descending too rapidly, but also their flight profile has taken them below the glideslope beam.

Further penetration of the outer envelope will reach the inner envelope. The static envelope for this inner Mode 1 envelope is illustrated in Figure 6.2.1-3, again assuming the bias term is zero. Here the voice warning will change from "Sinkrate" to "Pull Up" and the caution lamps will change to warning lamps if using Lamp Format 2. The static Mode 1 inner curve for turboprop airplanes (available on both MKVI and MKVIII EGPWS) is composed of two straight lines with the equations:

(lower line) RADIO ALTITUDE (FT) = -1625.47 (FT) - 1.1167 * ALTITUDE RATE (FPM)

(upper line) RADIO ALTITUDE (FT) = - 0.1958 * ALTITUDE RATE (FPM)

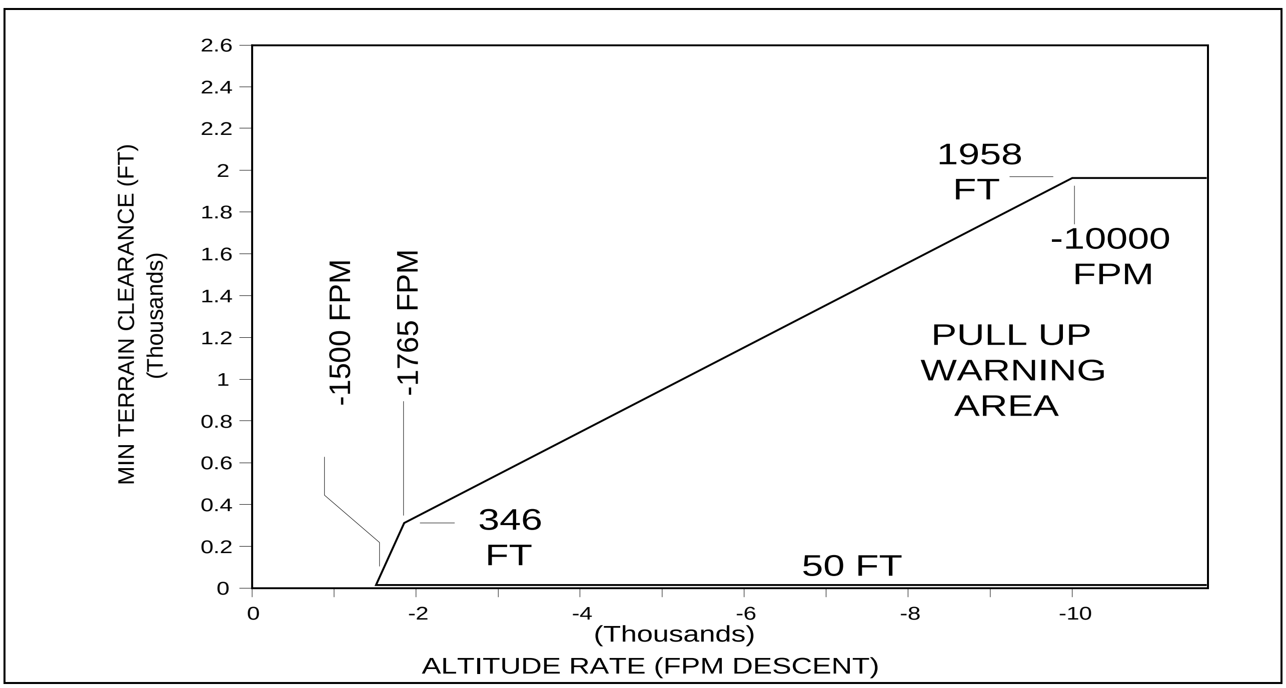


FIGURE 6.2.1-3: MODE 1 INNER CURVE (TURBOPROP)

The static Mode 1 inner curve for turbofan airplanes (available on MKVIII EGPWS only) is composed of two straight lines with the equations:

(lower line) RADIO ALTITUDE (FT) = -1620 (FT) - 1.1133 * ALTITUDE RATE (FPM)

(upper line) RADIO ALTITUDE (FT) = -400 (FT) - 0.4 * ALTITUDE RATE (FPM)

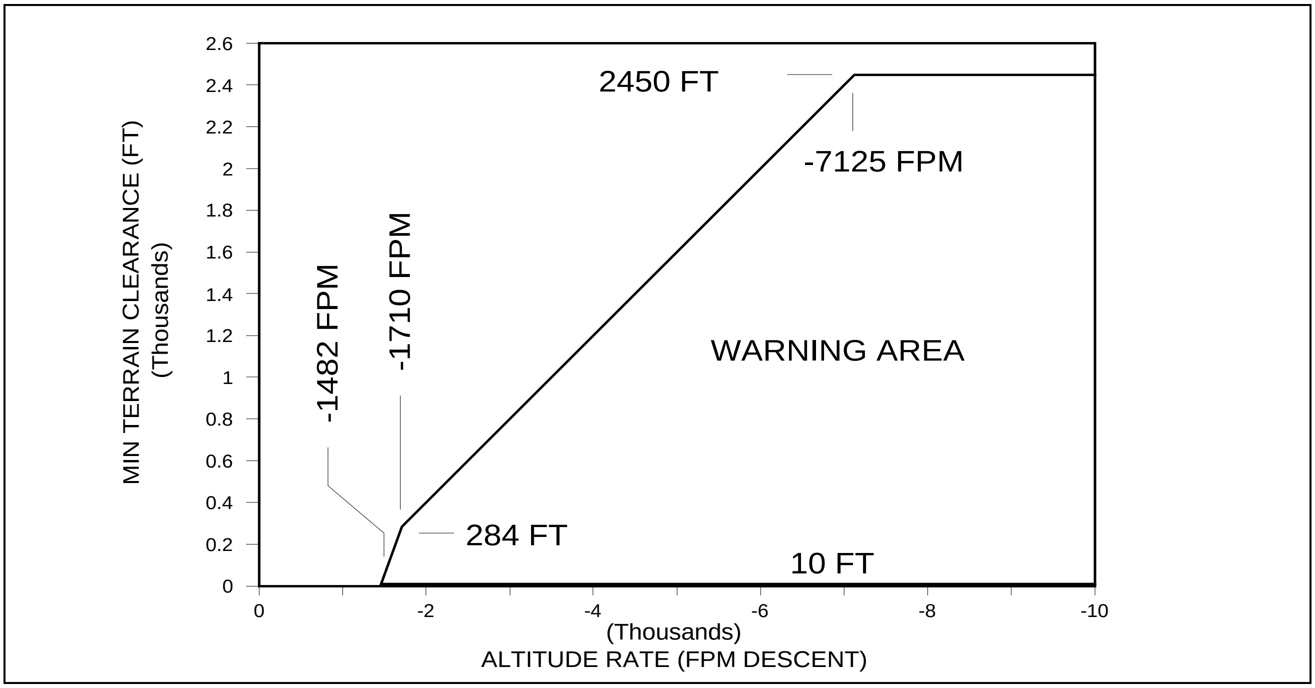


FIGURE 6.2.1-3A: MODE 1 INNER CURVE (TURBOFAN)

During normal conditions, the system will base Mode 1 computations upon barometric rate from the ADC. If this computed data is not valid or available then the system will use internally computed barometric altitude rate.

The presence of ground effect on the barometric rate data prevents its use close to the ground due to the potential for nuisance warnings. Consequently, Mode 1 is cut off at 50 feet radio altitude. Mode 1 is cut off at 10 feet radio altitude for turbofan aircraft.

The outer curve is effective below a radio altitude of 2450 feet. The inner curve is effective below a radio altitude of 1958 feet for Turboprop aircraft and 2450 feet for turbofan aircraft.

There is a 0.8 second delay for the "Sinkrate" caution to minimize nuisance alerts caused by momentary penetration of the outer envelope. There is a delay for the "Pull Up" warning to guarantee that at least one "Sinkrate" (or equivalent) message will be given before the "Pull Up" message starts.

Figure 6.2.1-4 indicates the actual Mode 1 caution/warning curves for turboprop aircraft (Figure 6.2.1-4A for turbofan), considering filter lags and time delays, for constant descent rates initiated from 2450 feet radio altitude over water or flat terrain. Both the outer and inner curves are shown.

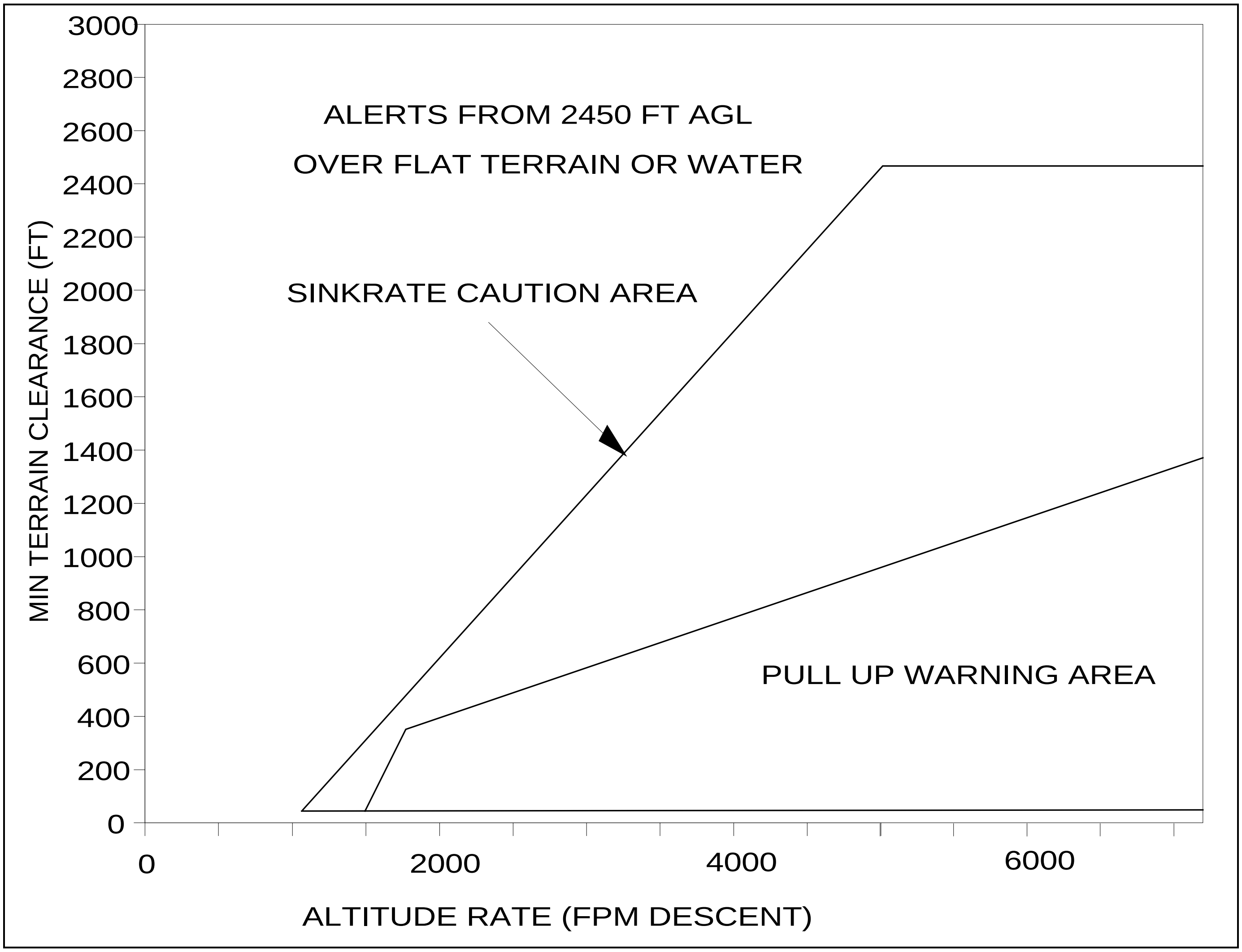


FIGURE 6.2.1-4: MODE 1 DYNAMIC ALERT ENVELOPE FROM 2450 FEET (TURBOPROP)

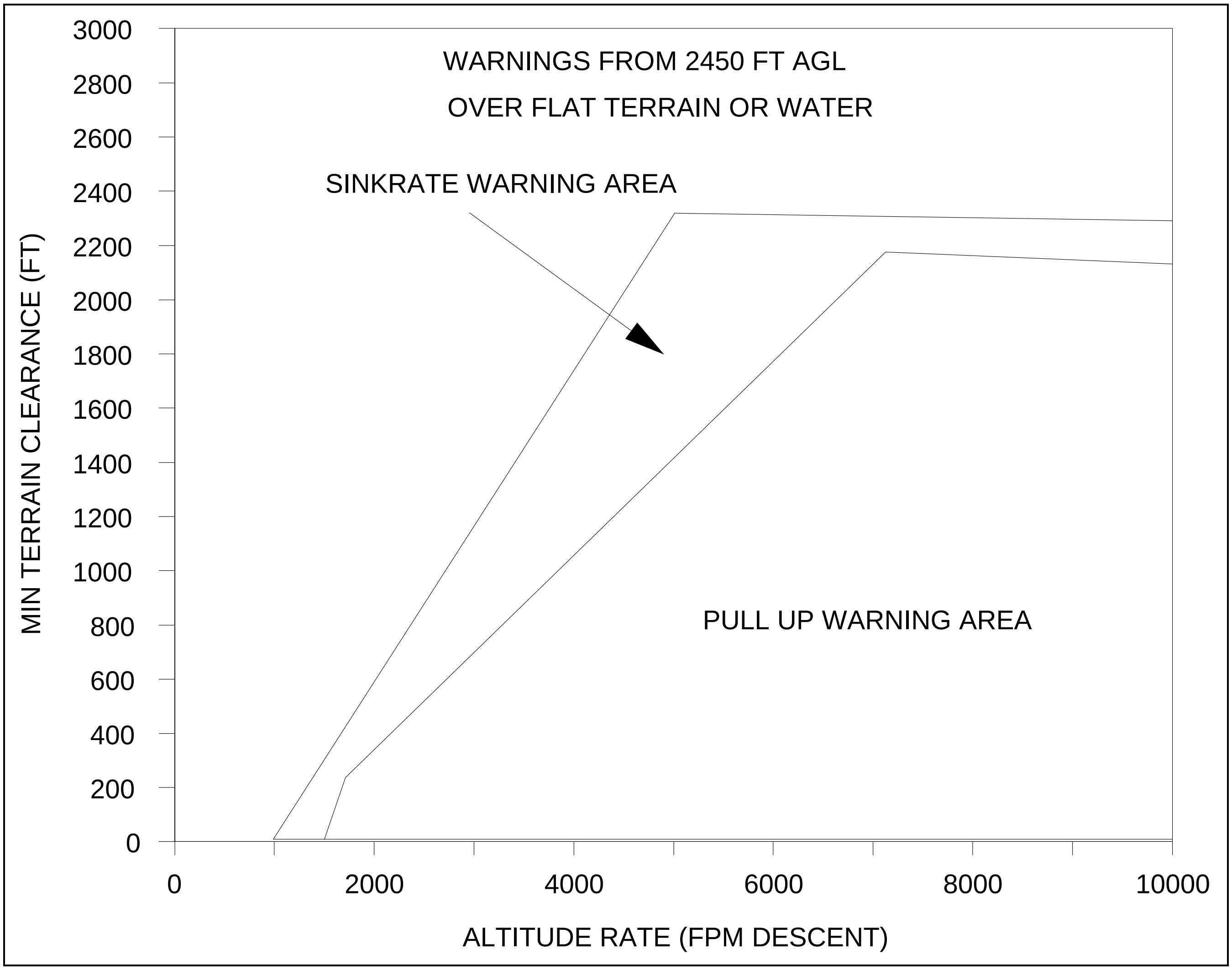


FIGURE 6.2.1-4A: MODE 1 DYNAMIC ALERT BOUNDARIES FROM 2450 FEET (TURBOFAN)

6.2.2 Mode 2 -- Excessive Terrain Closure Rate

Mode 2 provides two types of alerts based on aircraft gear/flap configuration, radio altitude (terrain clearance), and how rapidly that radio altitude is decreasing (closure rate). Barometric altitude of the airplane is not important in initiating this warning.

These two alerts are commonly referred to as Mode 2A, described in sections 6.2.2.1 and 6.2.2.2, and as Mode 2B, described in section 6.2.2.3.

Differentiating and scaling radio altitude generates closure rate. As the closure rate term is inherently noisy, especially over irregular terrain, extensive rate limiting and filtering must be used to obtain an accurate closure rate value for computation. The computer uses a number of different sets of sophisticated rate limits and filter methods to allow maximum sensitivity during cruise, while providing progressively less sensitivity during the landing phases of flight. These rate limits vary as a function of gear and flap position, aircraft speed, and whether or not the aircraft is on an ILS approach. It is this rate limiting and filtering that determines the effectivity of Mode 2 in providing advance alerts, while avoiding unwanted or nuisance alerts.

Altitude rate is combined with closure rate in the filtering method to provide "lead" information. Increasing the altitude descent rate will tend to speed up the alert occurrence. Reducing the altitude descent rate, or initiating a climb, will tend to delay the alert occurrence, or reduce the time that the alert is on.

Figure 6.2.2-1 shows the block diagram for Mode 2 alerts.

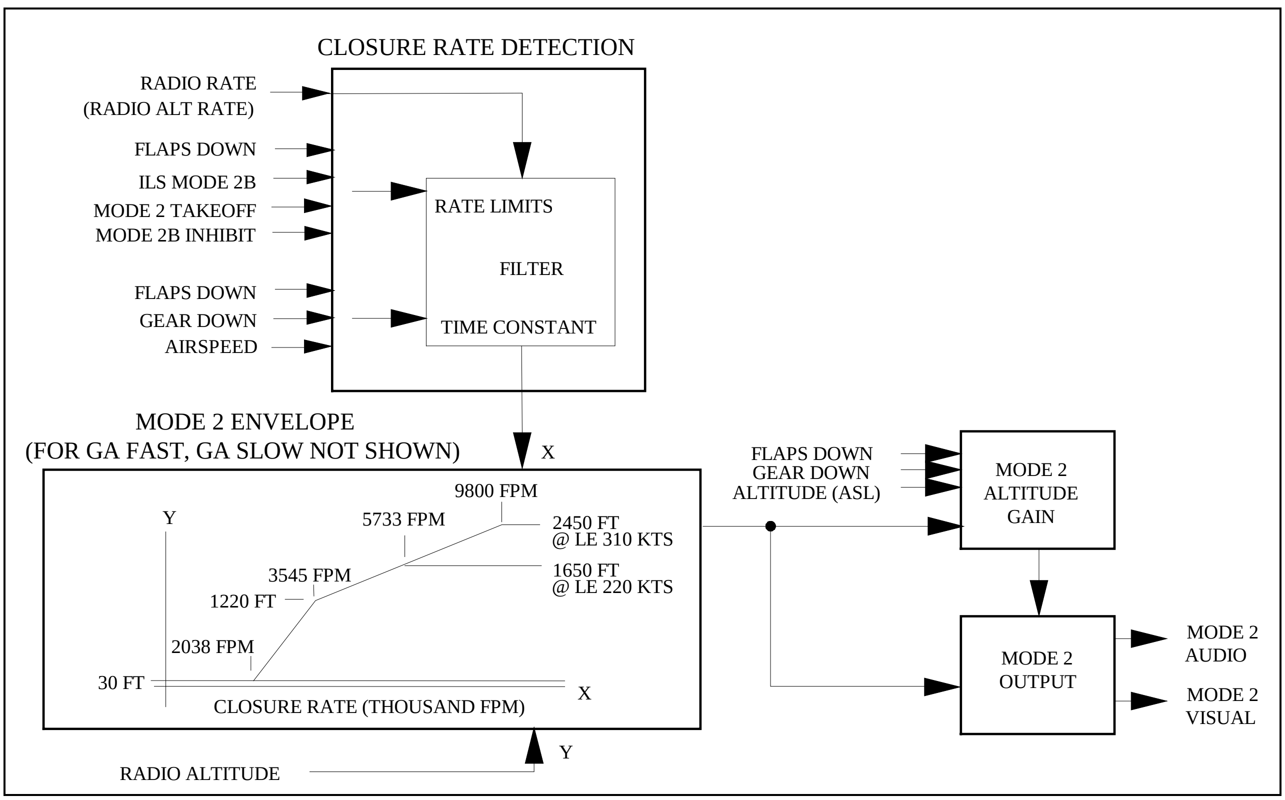


FIGURE 6.2.2-1: MODE 2 BLOCK DIAGRAM

Radio altitude, indicating the vertical distance between the aircraft and the underlying terrain, is differentiated to determine the rate of change in this vertical distance. Any decrease in this vertical distance indicates potential ground contact for the aircraft. Decreasing radio altitude may be the result of reducing the aircraft's altitude, an increase in height of the terrain, or a combination of both effects.

The computed closure rate is applied to the appropriate alert envelope, where the closure rate value is compared against the actual radio altitude value, to determine the alert conditions as described below.

6.2.2.1 Mode 2A

Mode 2A is operational when the flaps are not in the landing position. The maximum upper envelope is at 1650 feet radio altitude for speeds below 220 knots (for fast tuboprop, 190 knots for slow turboprop). As the aircraft speed increases up to 310 knots (for fast turboprop, 280 knots for slow turboprop), the upper altitude increases linearly to a maximum value of 2450 feet radio altitude. For speeds above these values, the upper altitude limit remains at 2450 feet. When the terrain awareness data is of a high integrity, the upper altitude limit is reduced to 1250 feet.

Figure 6.2.2.1-1 shows the static alert envelope for Mode 2A. Closure rate is the computed change in radio altitude between the aircraft and the ground, and is considered positive when the radio altitude is decreasing. Actual alerts will occur for conditions inside of this static envelope.

The lower sloped line of the static envelope for Mode 2A has an equation of:

MIN TERRAIN CLEARANCE (FT) = -1579 + 0.7895 [CLOSURE RATE (FPM)]

The upper sloped line has an equation of:

MIN TERRAIN CLEARANCE (FT) = 522 + 0.1968 [CLOSURE RATE (FPM)]

The lower boundary of this envelope is set at 50 feet radio altitude. The normal upper limit of the boundary is horizontal at 1650 feet radio altitude. As computed airspeed increases from 220 knots up to 310 knots (190 knots to 280 knots for slow turboprop) the upper boundary also linearly increases up to 2450 feet. The upper boundary is limited at certain airports (via envelope modulation) to reduce the warning sensitivity and minimize nuisance warnings.

Upon penetrating the envelope, either on the slope or from the top, the caution lights (warning lights for Lamp Format 1) come on and the voice message is “Terrain-Terrain”. If the envelope penetration lasts beyond these two messages by approximately 1 second, then the message switches to “Pull Up”, which is repeated continuously until the envelope is departed.

If the radio altitude monitor logic detects an invalid condition, or excessive closure rate due to a radio altimeter out of track condition, then all messages are cleared.

Due to previous terrain clearances, aircraft speed, and gear/flap configuration, the actual Mode 2A alert/warning envelope will be different than the static envelope illustrated in Figure 6.2.2.1-1.

Figure 6.2.2.1-2 shows the actual Mode 2A alert envelopes for two particular sets of terrain closure conditions. Here it is assumed for both conditions that the aircraft is flying at constant barometric altitude over flat terrain, at 2450 feet radio altitude. For the maximum expansion condition, airspeed is greater than 310 knots (280 knots for slow turboprop), landing gear and flaps are both retracted, and no glideslope signal is present. The closure rate begins from the 2450 foot radio altitude, and continues at a constant closure rate through the alert envelope. This is a typical scenario for inadvertent flight into a mountain during a holding pattern or initial approach. It is important to note that the actual upper limit is effectively around 2000 feet AGL, which is compatible with minimum instrument, terrain clearance procedures for mountainous terrain.

For the minimum expansion condition, airspeed is between 150 and 220 knots, landing gear and flaps are both retracted, and no glideslope signal is present. This set of conditions may not be realistic with the landing gear up, but is given as a comparative illustration.

The gear position will be equated to flap position on fixed gear aircraft to ensure that this logic work appropriately.

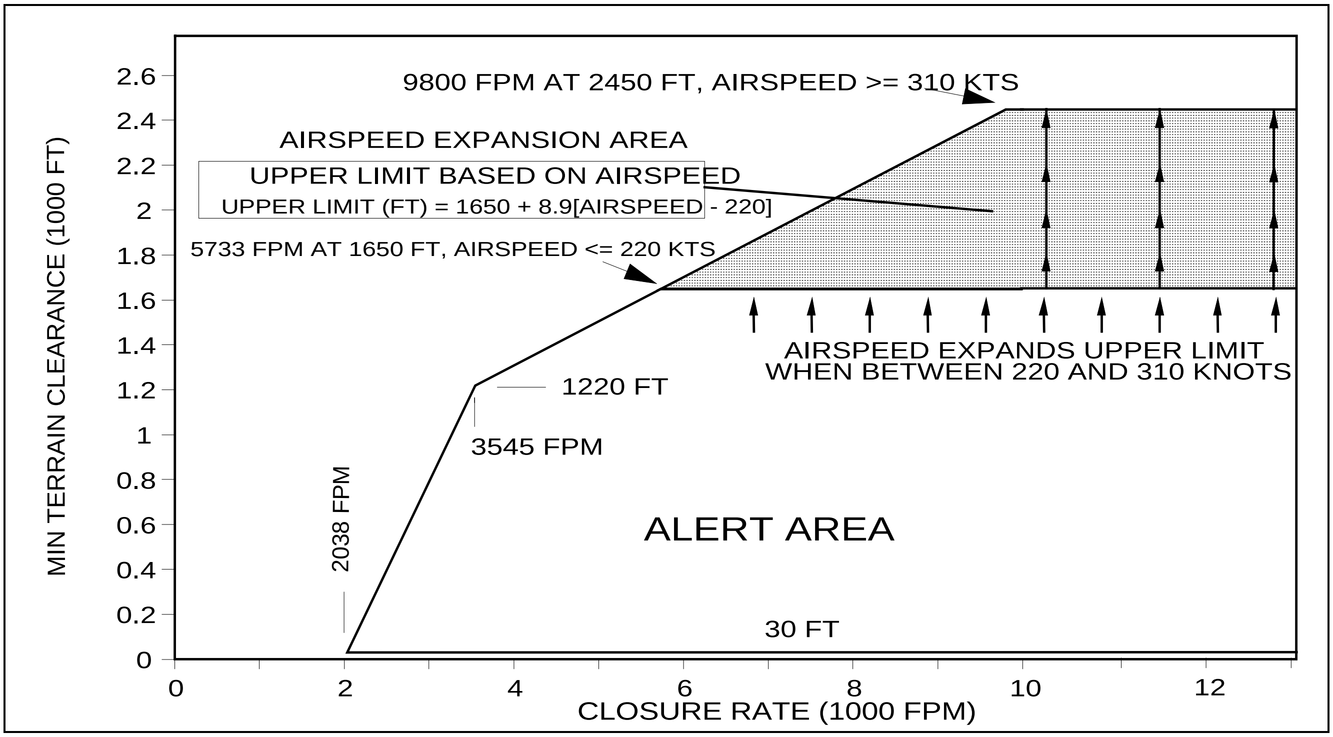


FIGURE 6.2.2.1-1: MODE 2 STATIC ENVELOPE (FAST TURBOPROP SHOWN)

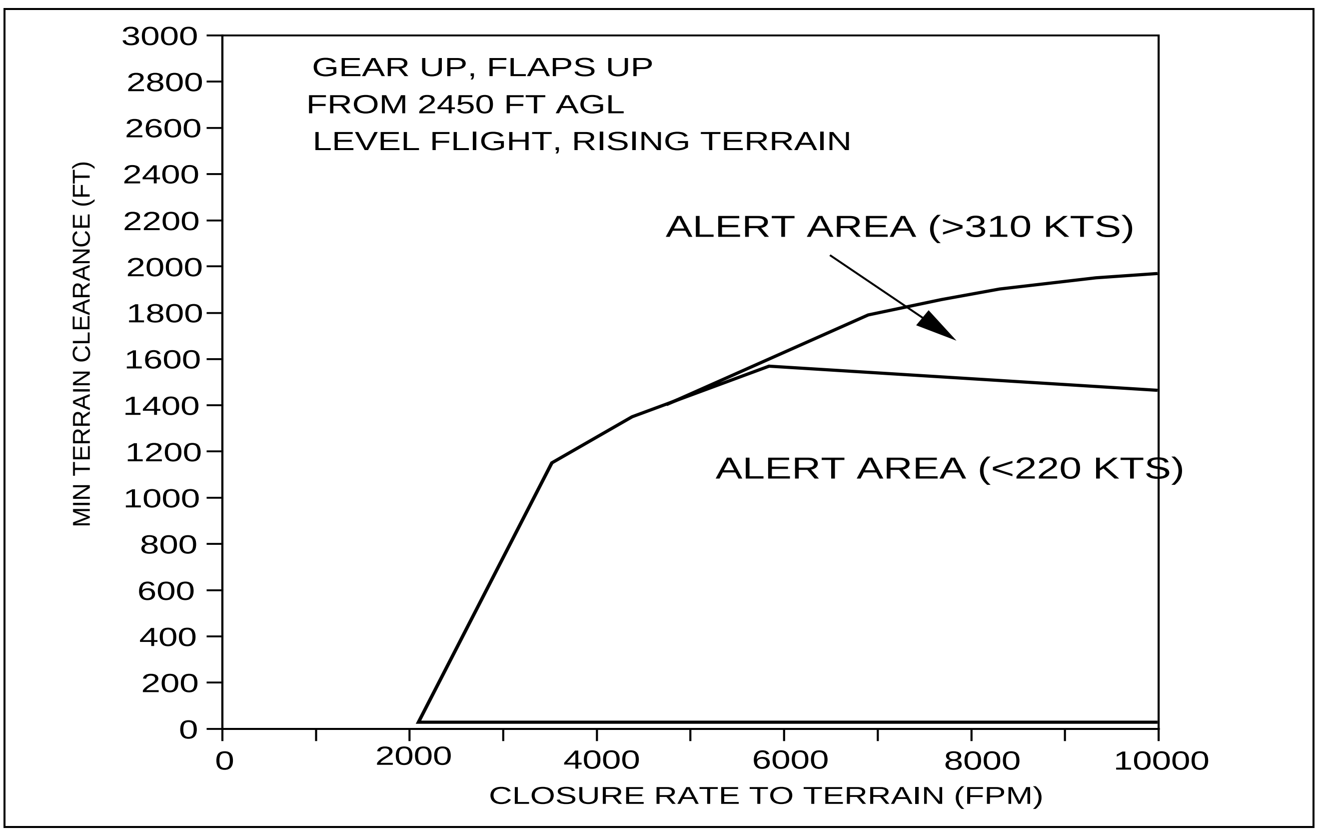


FIGURE 6.2.2.1-2: MODE 2 DYNAMIC ENVELOPE (FAST TURBOPROP SHOWN)

6.2.2.2 Mode 2A Altitude Gain

When the Mode 2A envelope is exited, after having been violated for more than 3 seconds, an altitude gain feature is automatically activated. Altitude (MSL) is sampled at this time to compute subsequent changes in altitude. The caution lights (warning lights if using Lamp Format 1) remain on, and if the terrain is still closing the voice message is “Terrain”.

After three hundred feet of Altitude (MSL) has been gained, or 45 seconds have elapsed from the point where the Pull-Up envelope was exited, all caution/warning lights and voices stop. The altitude gain requirement can also be canceled by momentarily selecting the flap override switch. If the terrain starts to fall away during this altitude gain time, the voice will shut off. In addition if the radio altimeter goes out of track (data NCD) then both the caution/warning lamp and voice are disabled.

If another envelope penetration occurs during this altitude gain time, and it lasts long enough to restart the “Pull Up” warning plus 3 seconds, then the whole process begins again with a new reference point for the 300 foot gain feature. In this manner the aircraft is directed up and over the terrain to a safer altitude.

6.2.2.3 Mode 2B

Lowering the flaps to the landing position automatically switches the system to Mode 2B as illustrated in 6.2.2.3-1. This static envelope is the same as the Mode 2A envelope, except the upper altitude boundary has been lowered to 789 feet, due to a maximum allowed closure rate of 3000 FPM.

The Mode 2B envelope is also selected with flaps up, when the aircraft is performing an ILS approach and glideslope is less than ±2 dots. However, the alert envelope is slightly different than the flaps down case, in that the lower boundary is controlled only as a function of radio altitude, having a constant lower cutoff of 30 feet AGL. Whenever the flaps are selected to the landing position the lower boundary of Mode 2B is desensitized in the region controlled by Figure 6.2.2.3-2.

The Mode 2B envelope is also selected automatically during the first 60 seconds after takeoff. This is to eliminate the false “Terrain” alerts that have occurred during certain cases of erroneous radio altitude tracking after takeoff. What occurs is typically a sharp increase, followed by a sharp decrease in the altitude output between 1000 and 1500 feet AGL. This Mode 2 ‘Takeoff’ mode effectively prevents Mode 2 alerts for altitudes above 789 feet AGL. This limit is also enabled when the TA&D functions are operating with high integrity (valid with good position and terrain data) and the aircraft is near an airport.

When the envelope for Mode 2B is penetrated, the caution/warning lamps come on, and the voice message is repeated until the envelope is exited. If the landing gear or flaps are up, then the voice message will be “Terrain-Terrain” or equivalent, followed by “Pull Up” if the condition persists. If both landing gear and flaps are in the landing configuration, then the message will be “Terrain”.

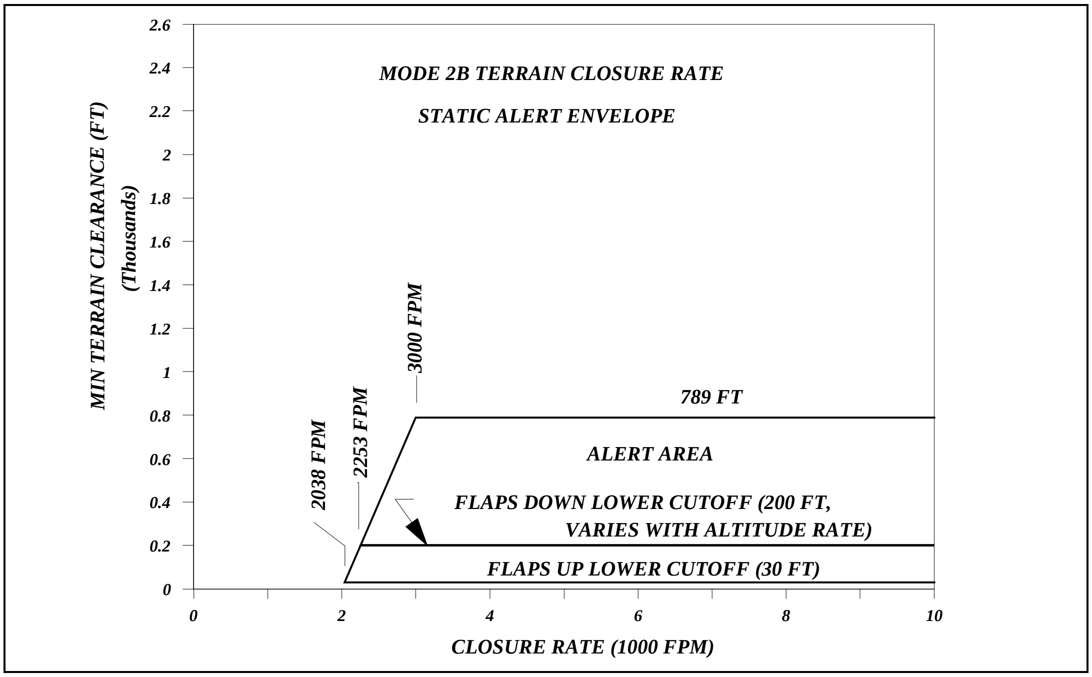


FIGURE 6.2.2.3-1: MODE 2B STATIC ENVELOPE

The lower part of the Mode 2B envelope is controlled as a function of radio altitude and altitude rate when flaps are in the full landing configuration, as shown in Figure 6.2.2.3-1.

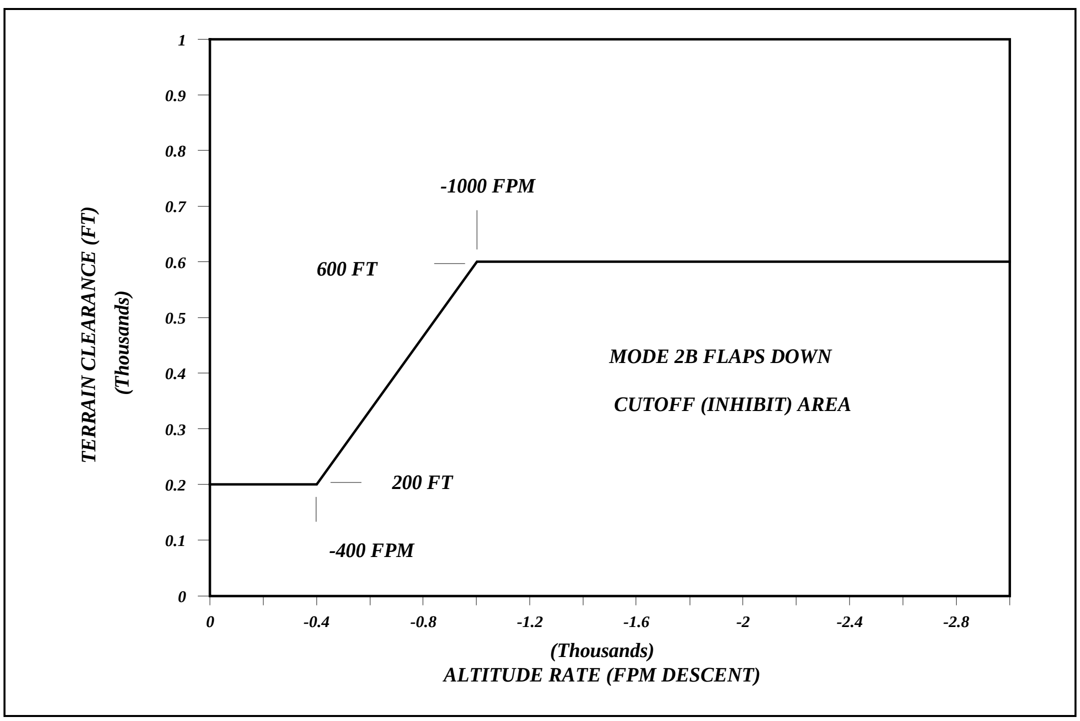


FIGURE 6.2.2.3-2: MODE 2B LOWER CUTOFF

The sloped portion of the Mode 2B Lower Cutoff in Figure 6.2.2.3-2 is represented by the equation:

TERRAIN CLEARANCE (FT)] = -66.777 - 0.667[ALTITUDE RATE (FPM)]

6.2.3 Mode 3 -- Descent After Takeoff

Mode 3 provides alerts for excessive altitude loss after takeoff

Mode 3 is based primarily on radio altitude, barometric altitude, and barometric altitude rate. Mode 3 is shown in the block diagram of Figure 6.2.3-1.

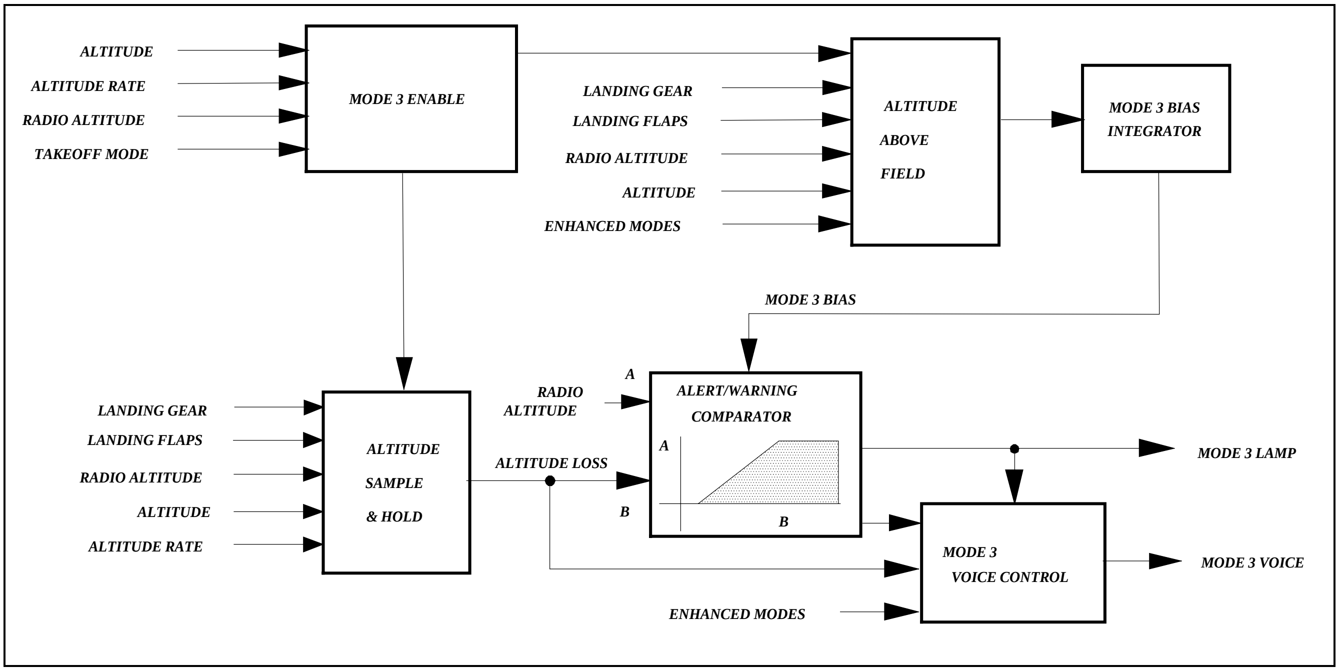


FIGURE 6.2.3-1: MODE 3 FUNCTIONAL BLOCK DIAGRAM

Penetration of the Mode 3 alert condition will result in the message "Don't Sink" and is based on altitude loss and radio altitude. This alert is only provided during takeoff when the aircraft loses a predetermined amount of altitude. Figure 6.2.3-2 illustrates the Mode 3 envelope for turboprop aircraft. Figure 6.2.3-2A illustrates the Mode 3 envelope for turbofan aircraft, available on MKVIII EGPWS only and selectable upon installation. The sloped portion of the static alert envelope depicted is defined by the following equation.

$$\text{ALTITUDE LOSS (FT)} = 5.4 + 0.092\ [\text{RADIO ALTITUDE (FT)}]$$

With flap override active (not applicable to turbofan aircraft):

$$\text{ALTITUDE LOSS (FT)} = 9.0 + 0.184\ [\text{RADIO ALTITUDE (FT)}]$$

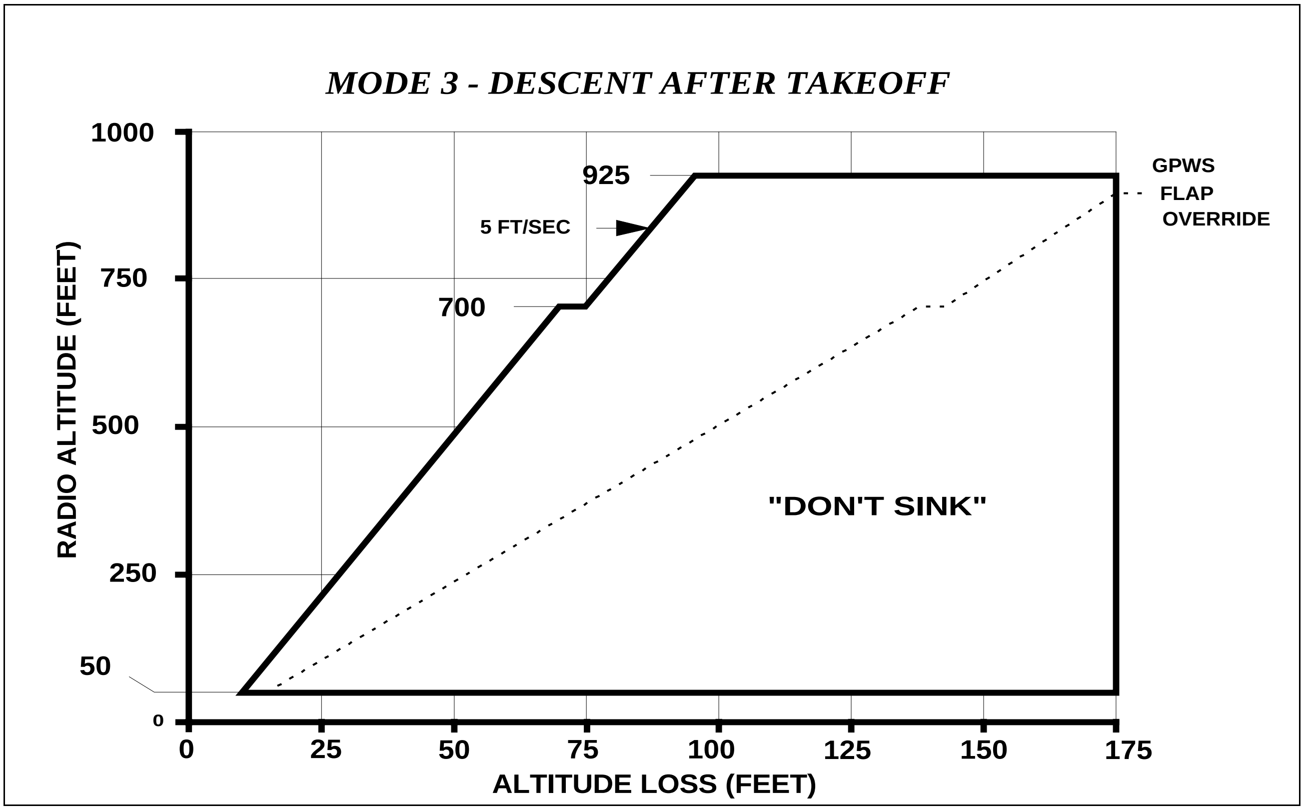


FIGURE 6.2.3-2: MODE 3 STATIC ALERT ENVELOPE (TURBOPROP)

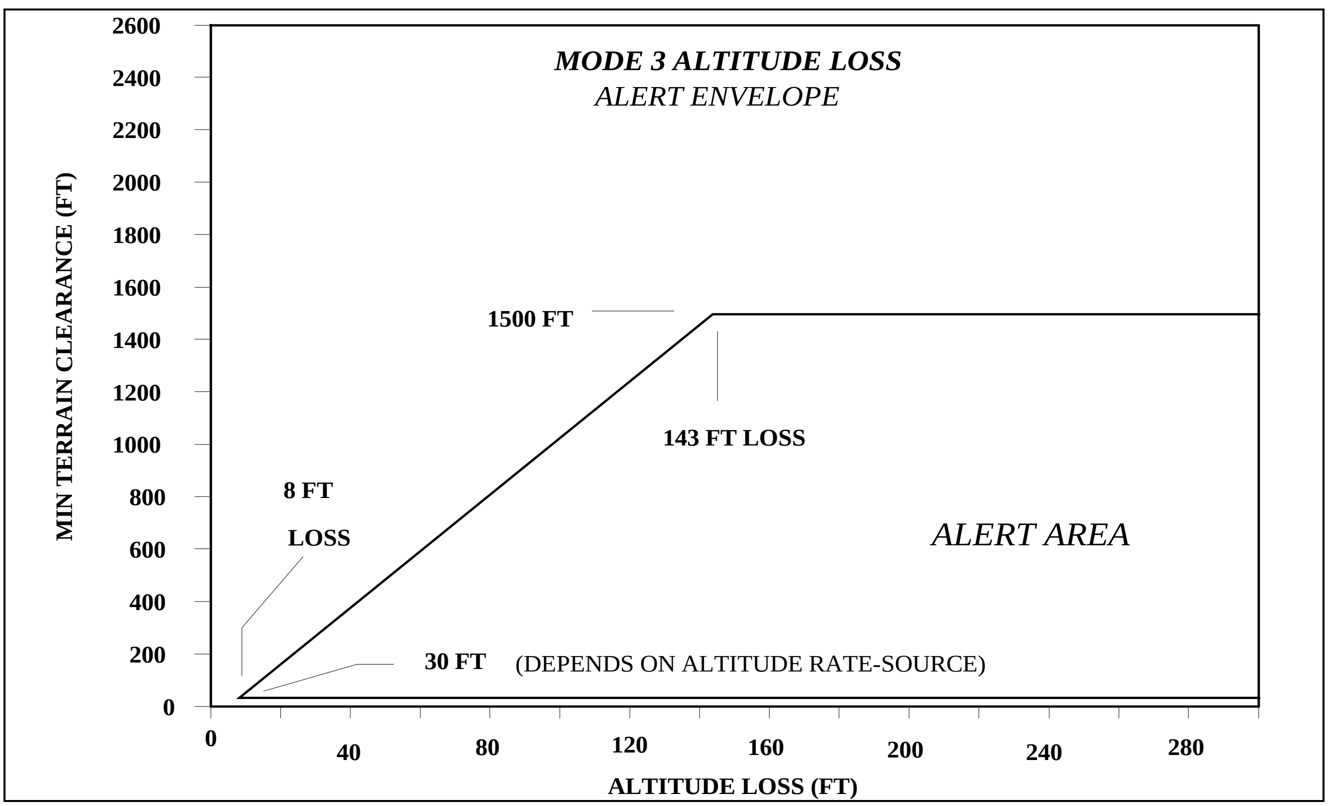


FIGURE 6.2.3-2A: MODE 3 STATIC ALERT ENVELOPE (TURBOFAN)

Barometric altitude rate is used in the same manner as was described for Mode 1. The Mode 3 alert envelopes are inhibited close to the ground.

The descent required for an alert varies as a function of flight profile and time. Once a descent begins during the takeoff phase of flight, as determined by the polarity of the altitude rate signal and takeoff/approach mode logic, the computer will store the existing value of altitude. Subsequent samples of altitude, altitude rate, and radio altitude are examined for alert conditions. The original stored value of altitude indicating where the descent began is retained until the aircraft ascends above the stored altitude value, or the radio altitude is greater than 925 feet AGL, (815 feet AGL with flap override active and 1500 feet for turbofan). When the polarity of the altitude rate signal indicates ascent rather than descent, the alert is cut off to indicate recovery is being initiated. A subsequent return to descent prior to regaining the altitude lost enables the alert. The altitude loss required to resume the message and lamps is based on the initially stored altitude value. In this manner, the possibility of stair stepping down without Mode 3 alert indication is eliminated.

Mode 3 is biased above 700 feet radio altitude at the rate of 5 additional feet of altitude loss per second. Selection of the GPWS flap override function increases the allowable altitude. This allows optional pattern work to be performed without unwanted warnings.

Mode 3 annunciation will typically give two messages, and then will bias the voice alert conditions an amount equal to 20% of radio altitude. If the aircraft does not lose this additional altitude, no further voice messages will be given. If, however, this altitude is also lost, then two additional messages will be given and another 20% bias of radio altitude added into the alert calculation. This process of ratcheting the voice alert continues until the original altitude is recovered. The caution/warning lamps are not affected and always remains on when the envelope is violated.

6.2.4 Mode 4 -- Unsafe Terrain Clearance

Mode 4 generates three types of voice alerts based on radio altitude, computed airspeed, and aircraft configuration, commonly referred to as Modes 4A, 4B, and 4C. Modes 4A and 4B static alert envelopes are illustrated in Figures 6.2.4.1-2 through -8. Dynamic envelopes are not included for these Modes because they do not differ significantly from the static cases. The Mode 4C static envelope is illustrated in Figure 6.2.4.2-2. A dynamic alert envelope for Mode 4C is illustrated in Figure 6.2.4.2-3.

6.2.4.1 Modes 4A and 4B

The MKVI and MKVIII EGPWS can use a normal or alternate airspeed range for Mode 4, which is determined by aircraft type (see Installation Design Guide). The alternate range is intended for those aircraft that fly more slowly, or have the capability of flying in the slower alternate range during approach if needed. The Figure 6.2.4.1-1 is a block diagram of Mode 4A and 4B.

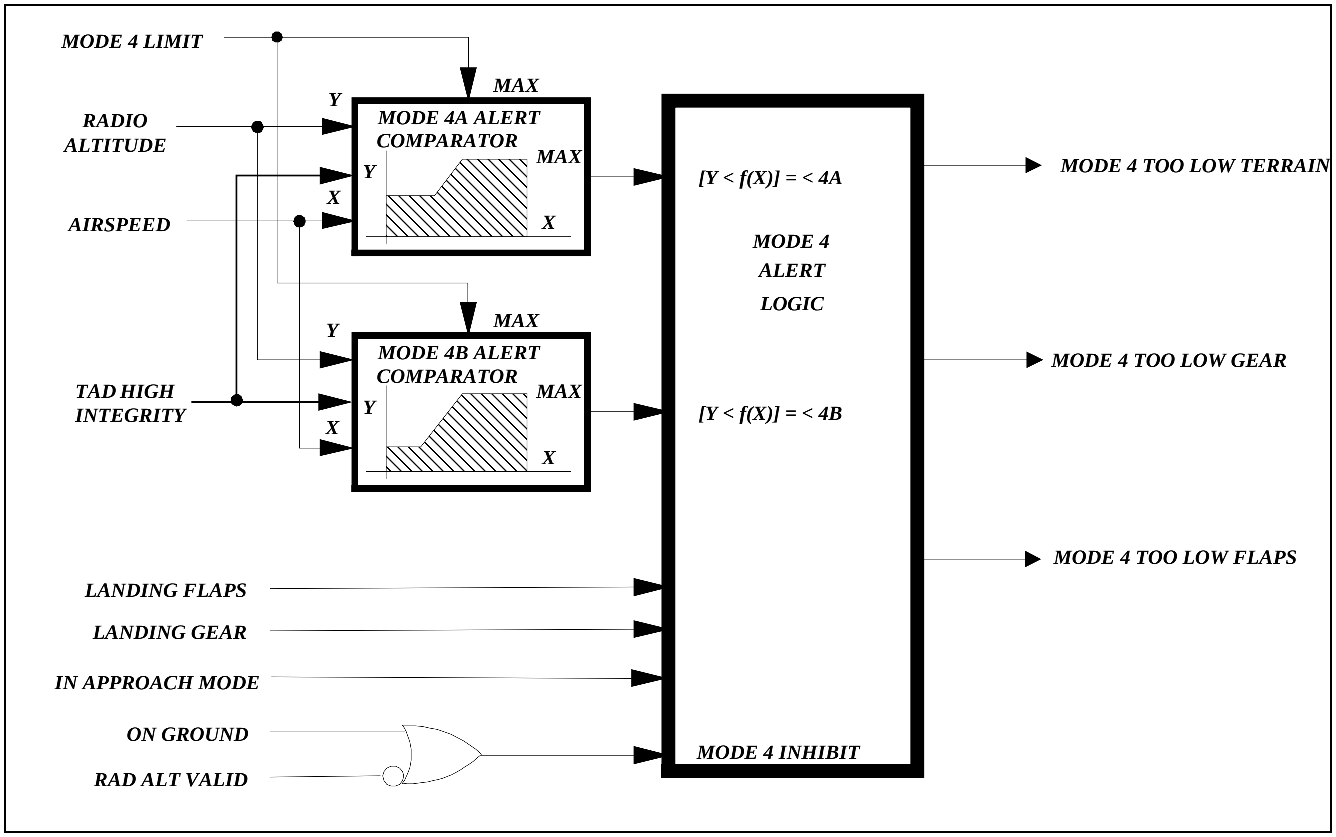


FIGURE 6.2.4.1-1: MODE 4A/4B FUNCTIONAL BLOCK DIAGRAM

For ease of use the following list of tables identifies which Mode 4 Types are depicted where:

- Figure 6.2.4.1-2 shows the Mode 4A envelope used by Mode 4 Types 6,8
- Figure 6.2.4.1-2A shows the Mode 4A envelope used by Mode 4 Type 5
- Figure 6.2.4.1-2B shows the Mode 4A envelope used by Mode 4 Type 1
- Figure 6.2.4.1-3 shows the Mode 4A envelope used by Mode 4 Types 7,9
- Figure 6.2.4.1-4 shows the Mode 4B envelope used by Mode 4 Type 5
- Figure 6.2.4.1-4A shows the Mode 4B envelope used by Mode 4 Type 1
- Figure 6.2.4.1-5 shows the Mode 4B envelope used by Mode 4 Type 6
- Figure 6.2.4.1-6 shows the Mode 4B envelope used by Mode 4 Type 7
- Figure 6.2.4.1-7 shows the Mode 4B envelope used by Mode 4 Type 8
- Figure 6.2.4.1-8 shows the Mode 4B envelope used by Mode 4 Type 9
- Figure 6.2.4.2-2 shows the Mode 4C envelope used by Mode 4 Type 6,7,8,9
- Figure 6.2.4.2-3 shows the Mode 4C envelope used by Mode 4 Type 5
- Figure 6.2.4.2-3A shows the Mode 4C envelope used by Mode 4 Type 1

The standard upper boundary for Mode 4A (turboprop aircraft) is at 500 feet radio altitude. If the aircraft penetrates this boundary with the gear still up, the voice message will be “Too Low Gear”. Above 178 knots (Mode 4 Types 5,6,8), or 148

knots (for Mode 4 Types 7,9) the upper boundary increases linearly with airspeed to a maximum of 750 feet radio altitude at 200 knots or more (170 knots for alternate airspeed range). One exception to this is for Mode 4 Type 5 where it increases to 200 knots at 1000 feet. Penetrating this boundary produces a repetitive "Too Low Terrain" message.

When TAD is operating with a high level of confidence the speed expasion is inhibited thus inhibiting the Mode 4 "Too Low Terrain" warnings above the "Too Low Gear" or "Too Low Flaps" floor. This applies to all aircraft types. A high level of confidence is when TA&D and TCF are functioning over a geographical area with high quality terrain data or large bodiew of water, and there is a high degree of estimated accuracy in horizontal position and vertical positon.

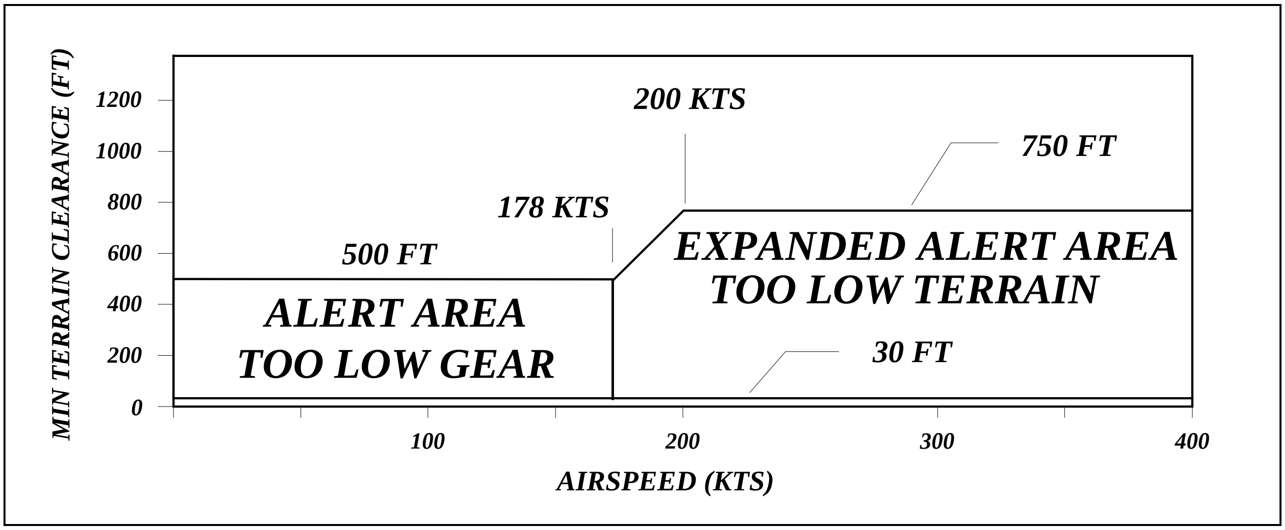


FIGURE 6.2.4.1-2: MODE 4A STATIC ALERT ENVELOPE (NORMAL AIRSPEED EXPANSION, MODE 4 TYPES 6,8)

Through Envelope Modulation other maximums are used at certain airports to minimize nuisance warnings.

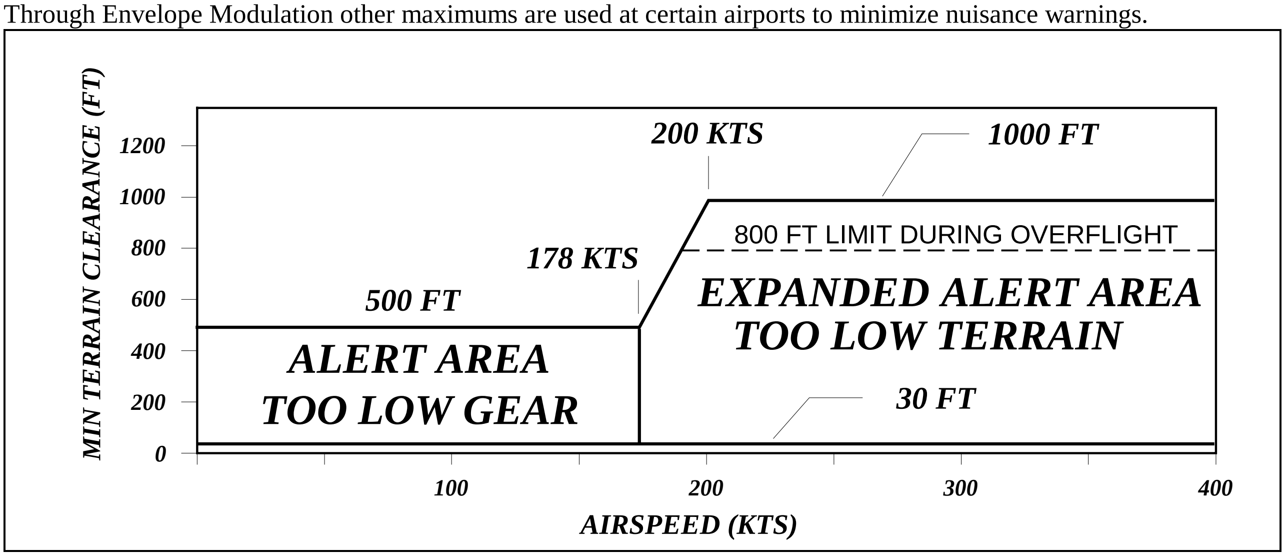


FIGURE 6.2.4.1-2A: MODE 4A STATIC ALERT ENVELOPE (NORMAL AIRSPEED EXPANSION, MODE 4 TYPE 5)

The standard upper boundary for Mode 4A (turbofan aircraft) is at 500 feet radio altitude. If the aircraft penetrates this boundary with the gear still up, the voice message will be "Too Low Gear". Above 190 knots the upper boundary increases linearly with airspeed to a maximum of 1000 feet radio altitude at 250 knots or more. Penetrating this boundary produces a repetitive "Too Low Terrain" message. See Figure 6.2.4.1-2B for a pictorial representation of the alerts.

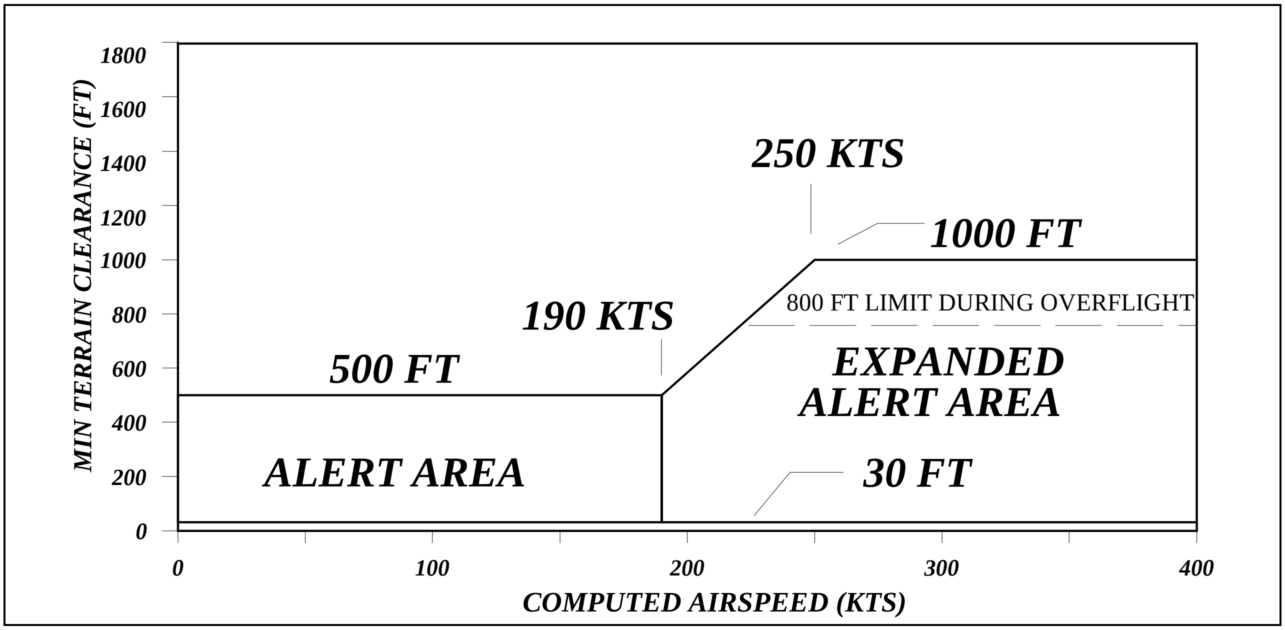


FIGURE 6.2.4.1-2B: MODE 4A STATIC ALERT ENVELOPE FOR TURBOFAN (MODE 4 TYPE 1)

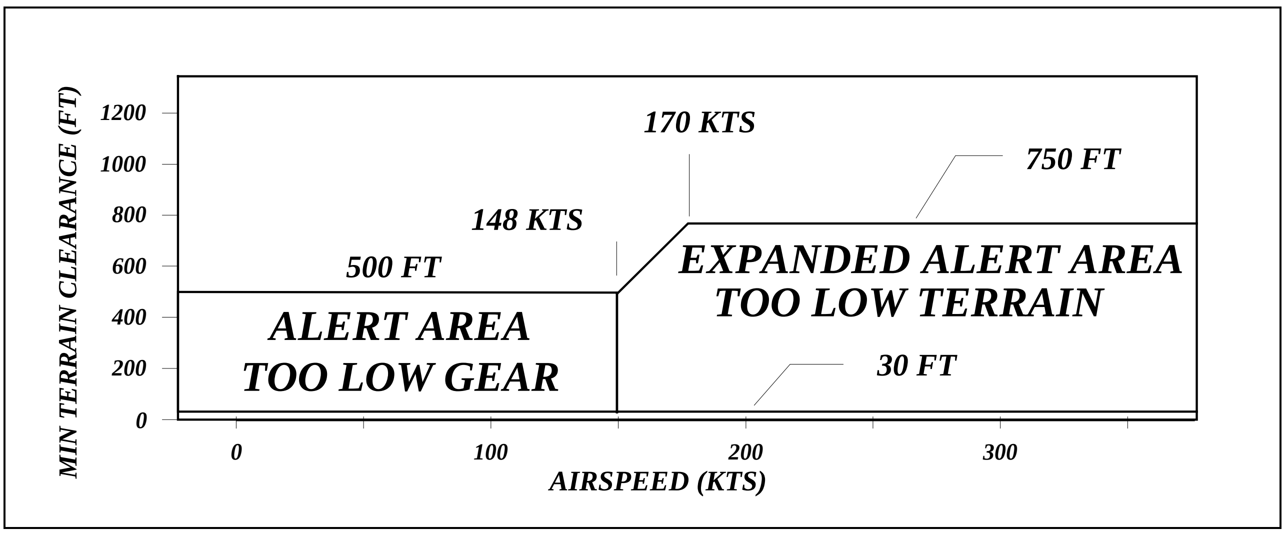


FIGURE 6.2.4.1-3: MODE 4A STATIC ALERT ENVELOPE (ALTERNATE AIRSPEED EXPANSION, MODE 4 TYPES 7,9)

Figure 6.2.4.1-2, 6.2.4.1-2A, and 6.2.4.1-3 detail the three Mode 4A options for the MKVI EGPWS. The MKVIII EGPWS has these options as well as the turbofan boundaries as shown in Figure 6.2.4.1-2B. Figures 6.2.4.1-2 and 6.2.4.1-2A depicts the normal airspeed expansion, Figure 6.2.4.1-3 the alternate airspeed expansion and Figure 6.2.4.1-2B the curve for turbofan aircraft, only. The alternate airspeed expansion may be used by any aircraft capable of flying the slow approach speeds as a matter of routine. If alternate airspeed expansion is used for Mode 4A it must also be used for Mode 4B. The turbofan curves are only available on the MKVIII EGPWS. If this is the selection for Mode 4A, it must be selected for all Mode 4 curves.

When the landing gear is lowered, the Mode 4B alert envelope is selected. The upper boundary decreases to 170 feet (Mode 4 Types 6 and 7) or 245 feet on turbofan aircraft (Mode 4 Type 1). This is reduced to 150 feet on those aircraft types that routinely delay full flap deployment (Mode 4 Types 8 and 9). The action of lowering the gear is recorded in nonvolatile memory to prevent inadvertent reactivation of the 500 foot Mode 4A boundary after a power loss. To satisfy customer requirements, Mode 4B has been modified to produce Mode 4 Type 5. For this type only, the upper boundary decreases to 200 feet.

The following paragraph explains the Mode 4B behavior for turboprop aircraft. Penetration of the Mode 4B envelope below 150 knots (Mode 4 Type 6), or alternatively 120 knots (Mode 4 Type 7) with gear up results in “Too Low Gear” (per Mode

4A) or with landing gear down and flaps not in landing position (and not overridden) “Too Low Flaps”. For aircraft types that routinely delay full flap deployment (Mode 4 Types 8 and 9) these airspeeds are 148 knots and 118 knots respectively.

To maintain the same airspeed expansion function up to 750 feet nominal at 200 knots the lower level “corner” is at 150 knots (Mode 4 Type 6), or 120 knots (Mode 4 Type 7) while above this airspeed the message is “Too Low Terrain”. For aircraft types that routinely delay full flap deployment (Mode 4 Types 8 and 9) these airspeeds are 148 knots and 118 knots respectively.

Mode 4B is slightly modified for turboprop aircraft (Mode 4 Type 1). Penetration of the Mode 4B envelope below 159 knots with gear up results in “Too Low Gear” or with landing gear down and flaps not in landing position (and not overridden) “Too Low Flaps”. To maintain the same airspeed expansion function up to 1000 feet at 250 knots the lower level “corner” is at 159 knots while above this airspeed the message is “Too Low Terrain”.

The “Too Low Gear” voice will be substituted with “Too Low Flaps” and the condition will be based on flaps up in lieu of gear up.

The Mode 4B envelope can also be selected by setting flaps to landing configuration or by selecting flap override. This provides the means to allow additional maneuvering room for marginal performance go-arounds (e.g. engine out).

The airspeed expansions for Mode 4A and 4B are disabled when Terrain Awareness data is of high integrity.

The equation for the sloped portion of the alert curves for Mode 4A is:

MIN TERRAIN CLEARANCE (FT) = -1523 + 11.36 [CAS (KNOTS)] – normal airspeed range

MIN TERRAIN CLEARANCE (FT) = -1182+ 11.36 [CAS (KNOTS)] – alternate airspeed range

The equation for the sloped portion of the alert curves for Mode 4B is:

MIN TERRAIN CLEARANCE (FT) = -1570 + 11.6 [CAS (KNOTS)] – normal airspeed range

MIN TERRAIN CLEARANCE (FT) = -1222+ 11.6 [CAS (KNOTS)] – alternate airspeed range

The equation for the sloped portion of the alert/warning curves on turbofan aircraft for both Mode 4A and 4B is:

MIN TERRAIN CLEARANCE (FT) = -1083 + 8.333 [CAS (KNOTS)]

A ratchet function is applied to the Mode 4 voice that is similar to the Mode 3 ratcheting voice message. Once the message is given, the envelope is biased down by 20% and further alerts are held off until this additional 20% radio altitude is lost. The caution/warning lamps are not affected and will remain on until the radio altitude becomes greater than the curves of Figures 6.2.4.1-2 through 6.2.4.1-8.

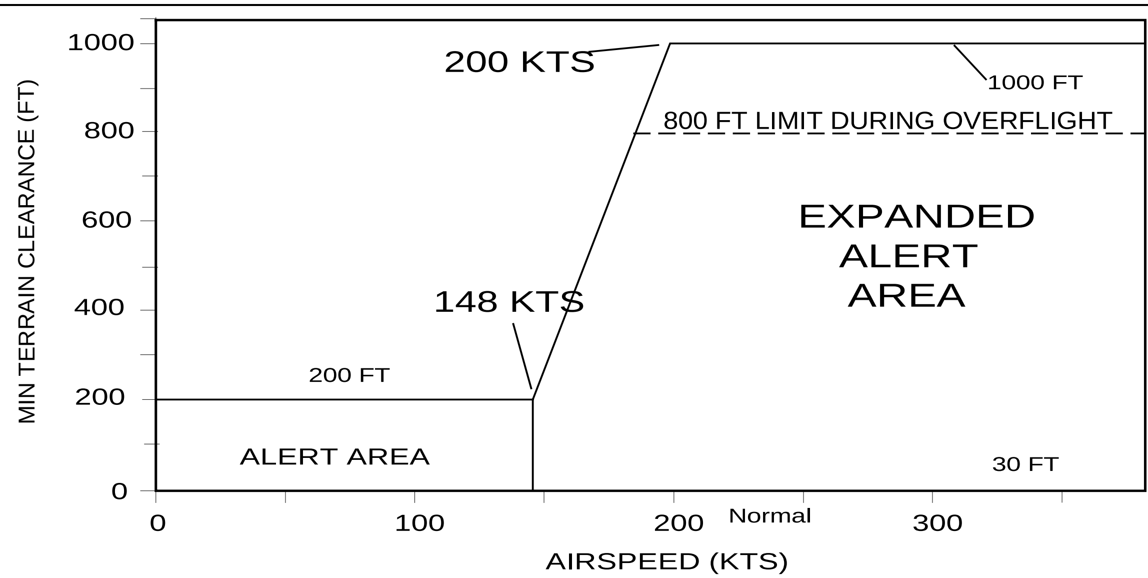


FIGURE 6.2.4.1-4: MODE 4B STATIC ALERT ENVELOPE (NORMAL AIRSPEED EXPANSION, MODE TYPE 5)

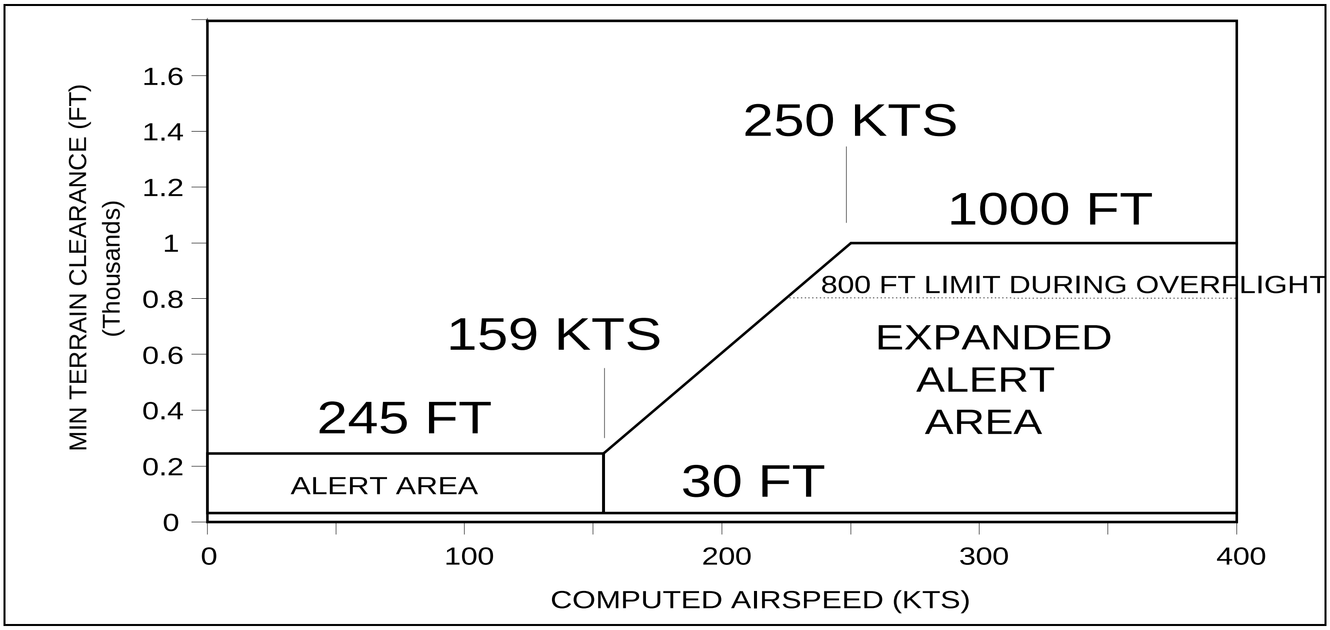


FIGURE 6.2.4.1-4A: MODE 4B STATIC ALERT ENVELOPE (TURBOFAN – MODE 4 TYPE 1)

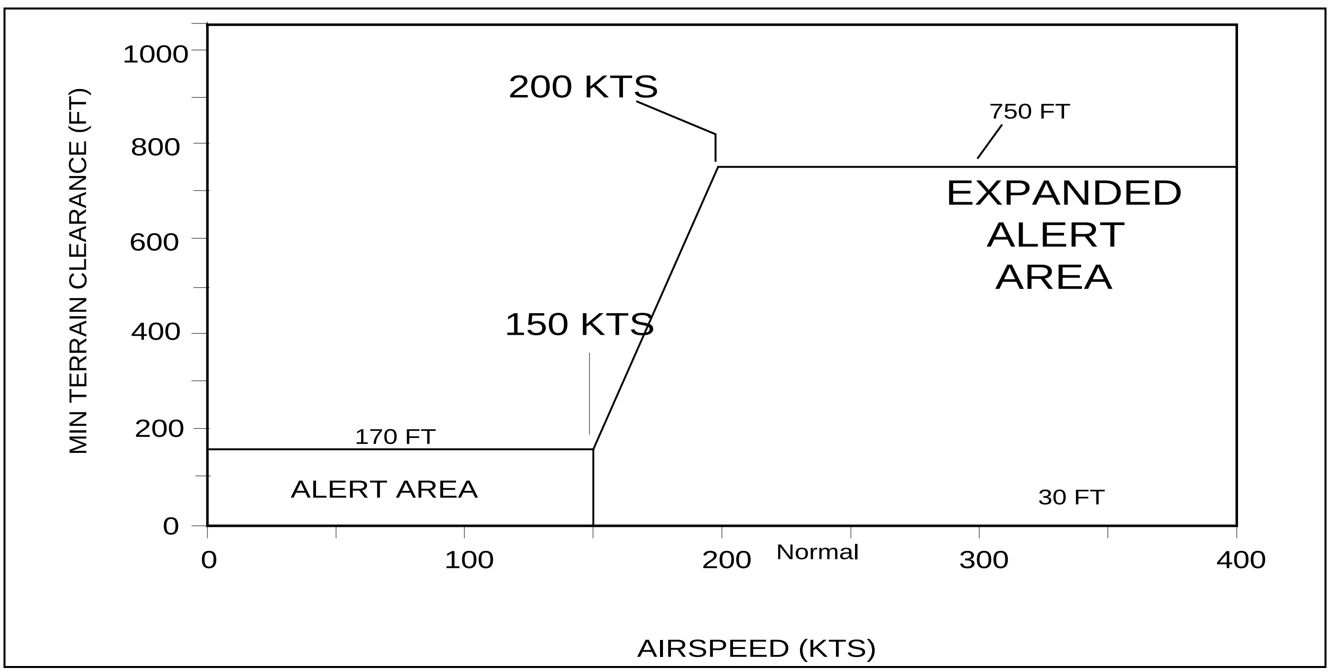


FIGURE 6.2.4.1-5: MODE 4B STATIC ALERT ENVELOPE (NORMAL AIRSPEED EXPANSION, MODE TYPE 6)

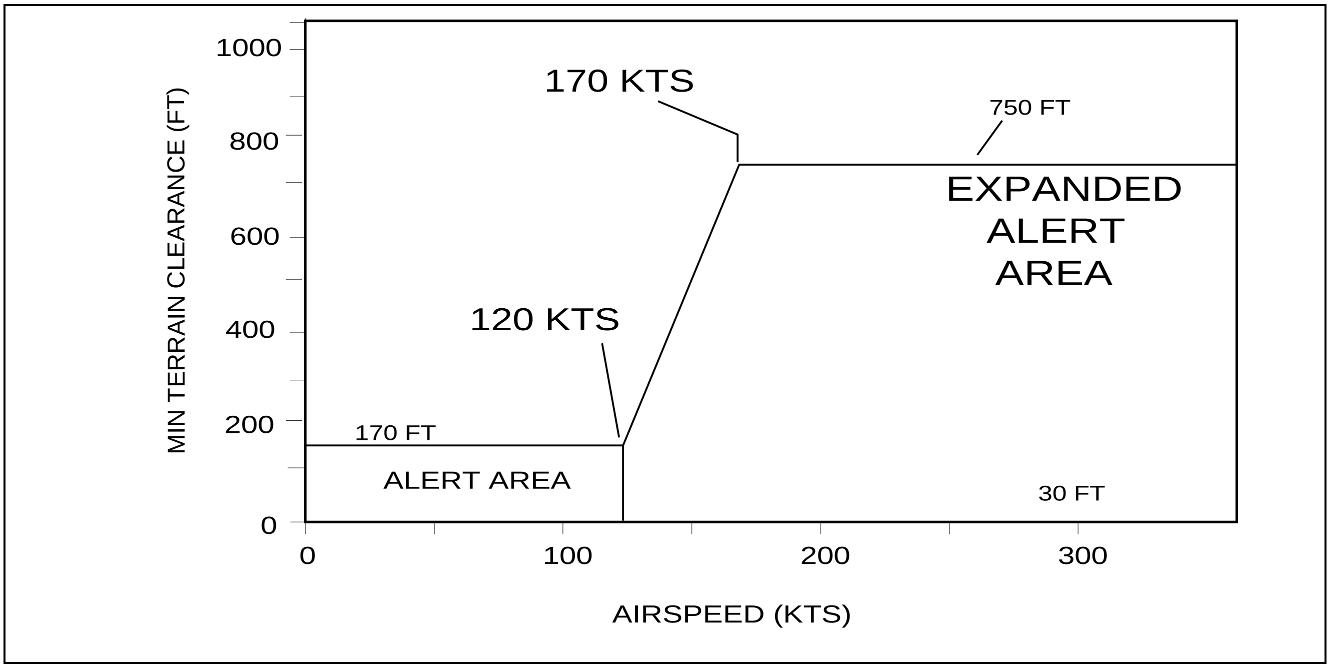


FIGURE 6.2.4.1-6: MODE 4B STATIC ALERT ENVELOPE (ALTERNATE AIRSPEED RANGE, MODE TYPE 7)

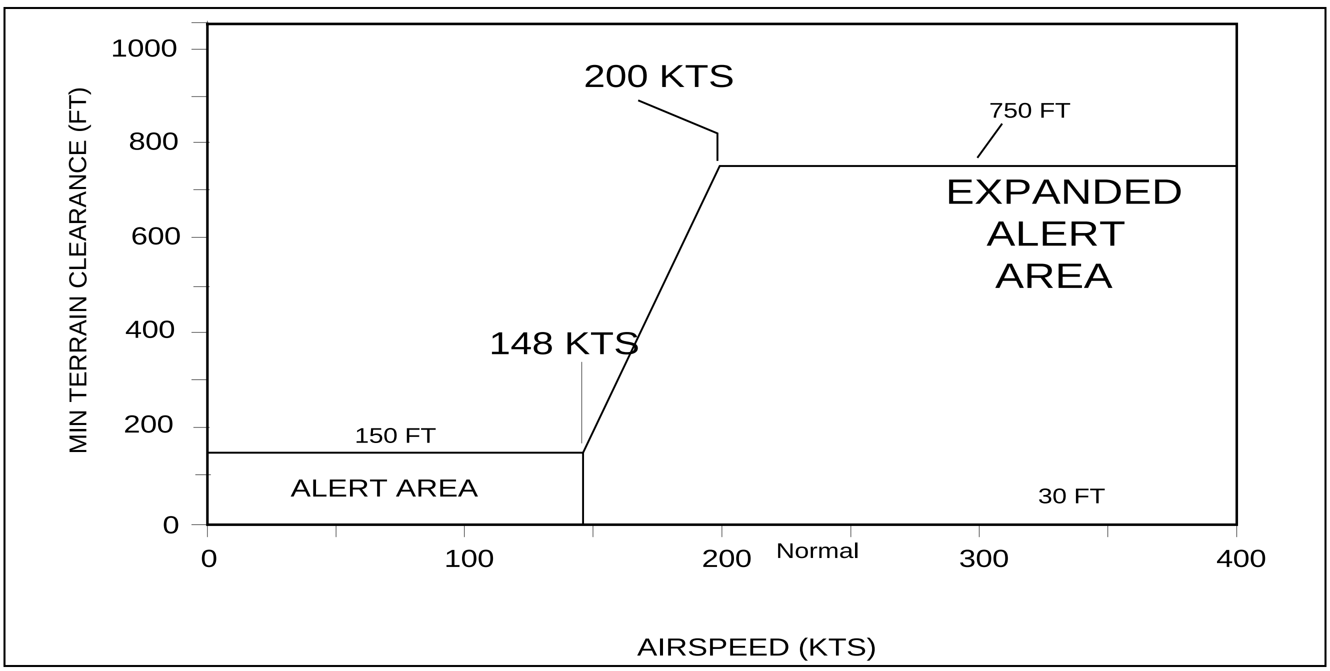


FIGURE 6.2.4.1-7: MODE 4B STATIC ALERT ENVELOPE (NORMAL AIRSPEED EXPANSION, MODE TYPE 8)

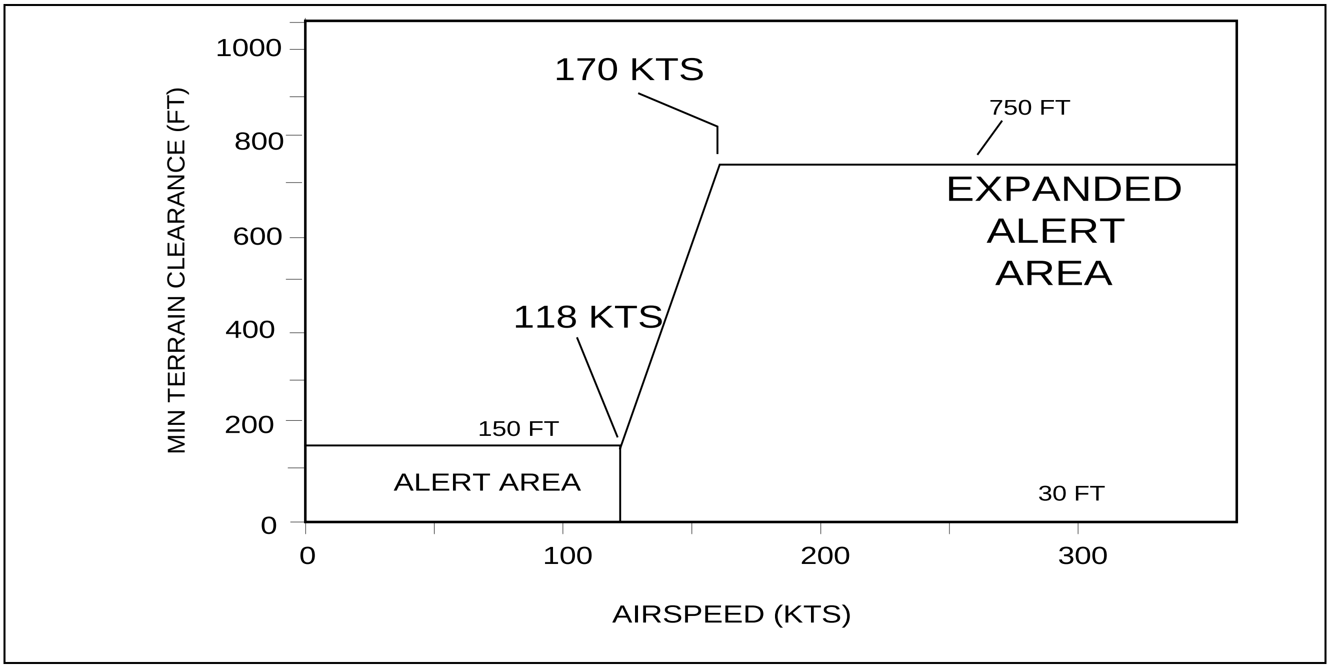


FIGURE 6.2.4.1-8: MODE 4B STATIC ALERT ENVELOPE (ALTERNATE AIRSPEED RANGE, MODE TYPE 9)

6.2.4.2 Mode 4C

Mode 4 also provides an alert based on minimum radio altitude clearance during takeoff as illustrated in Figure 6.2.4.2-1. This alert is similar to the Mode 4A alert that is active during the cruise and approach phases of flight, only in this case, the minimum terrain clearance is a function of the radio altitude of the aircraft. The sloped portion of the envelope boundary is described by the equation:

MIN TERRAIN CLEARANCE (FT) = 0.75 [RADIO ALTITUDE (FT)]

Figure 6.2.4.2-1 is a block diagram of Mode 4C. The actual Mode 4C envelopes are shown in Figures 6.2.4.2-2 through -3A.

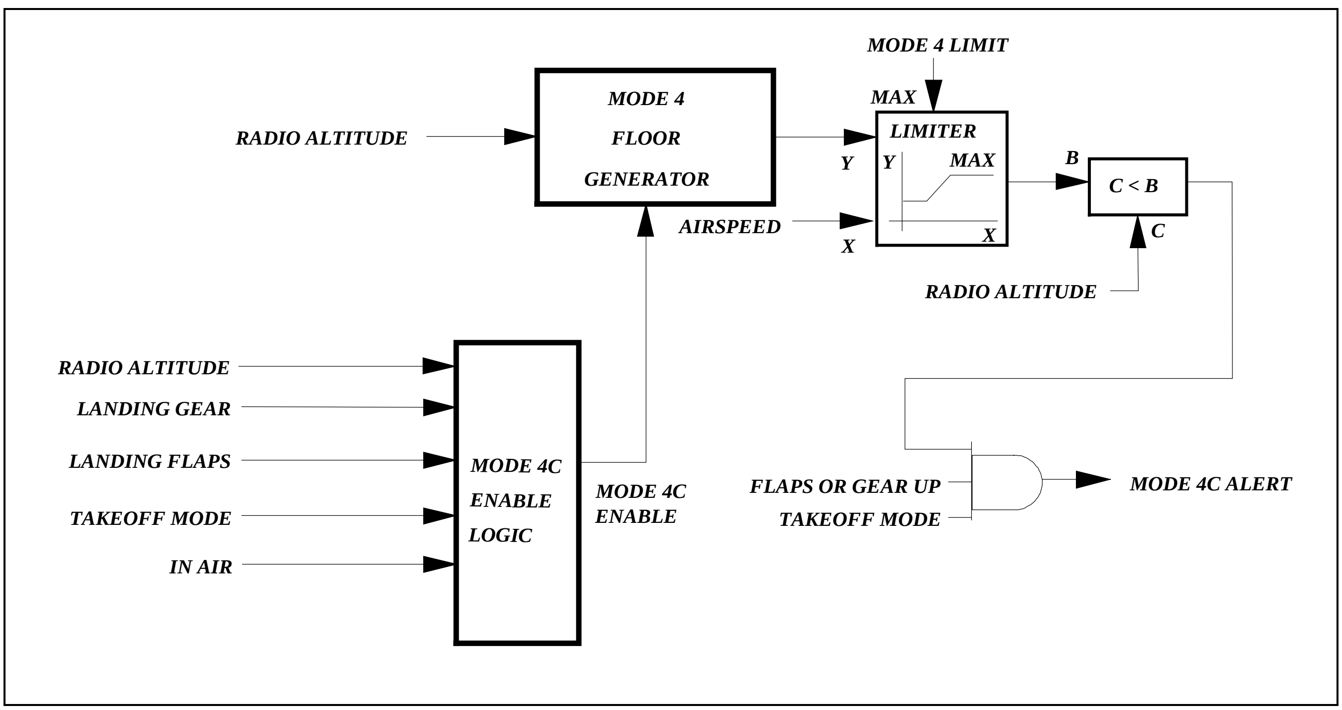


FIGURE 6.2.4.2-1: MODE 4C BLOCK DIAGRAM

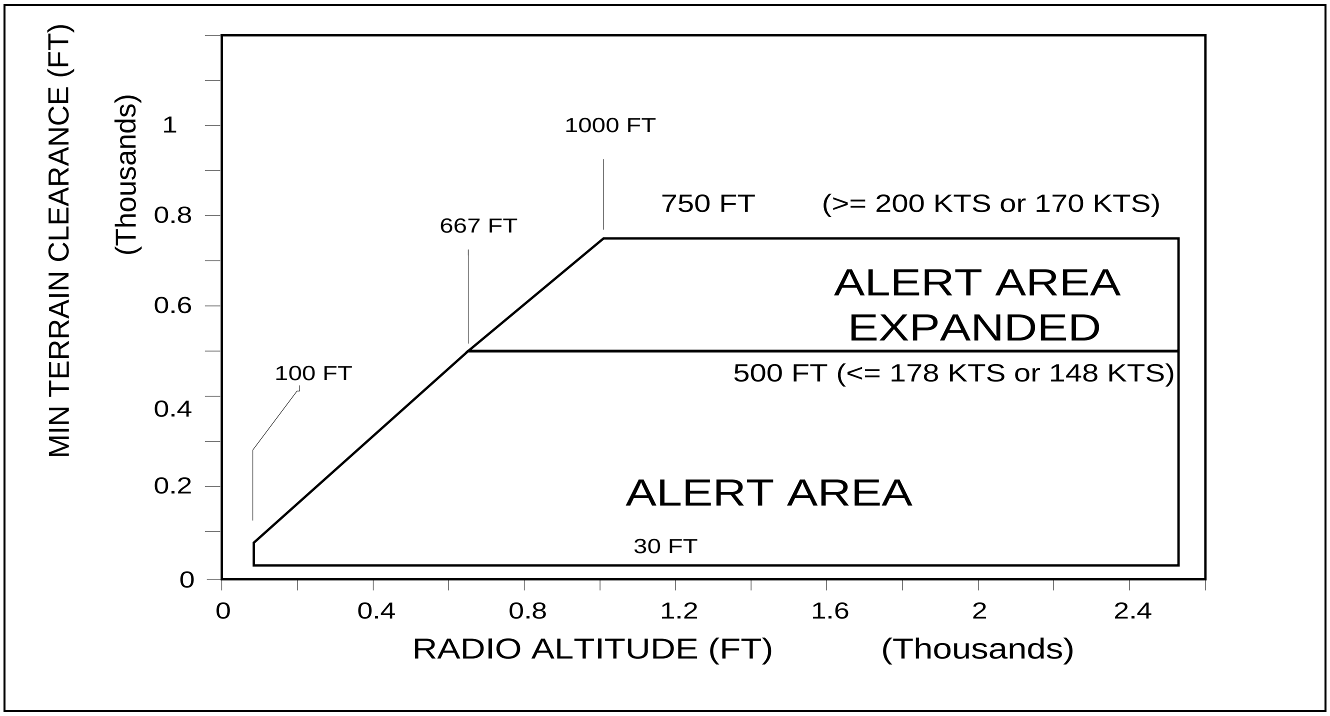


FIGURE 6.2.4.2-2: MODE 4C STATIC ALERT ENVELOPE (MODE 4 TYPES 6,7,8,9)

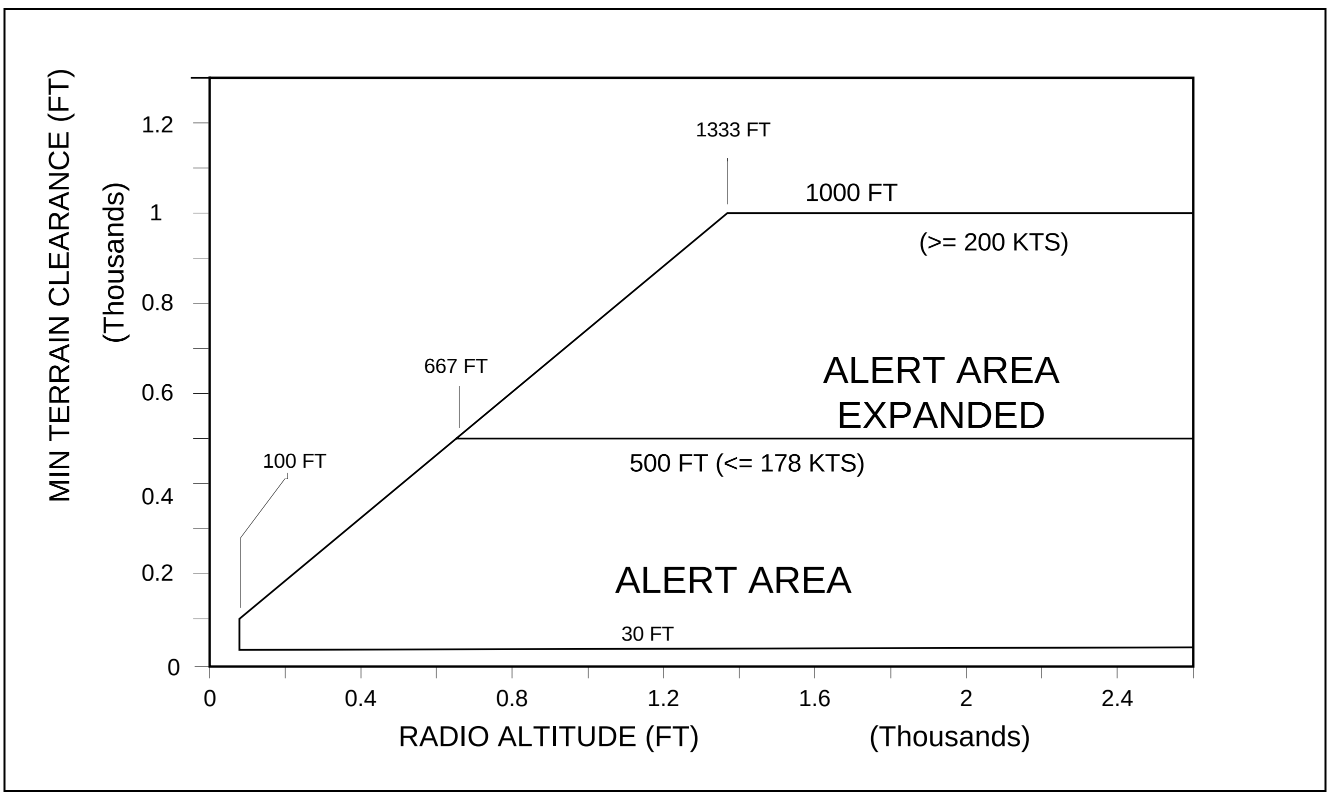


FIGURE 6.2.4.2-3: MODE 4C STATIC ALERT ENVELOPE (MODE 4 TYPE 5)

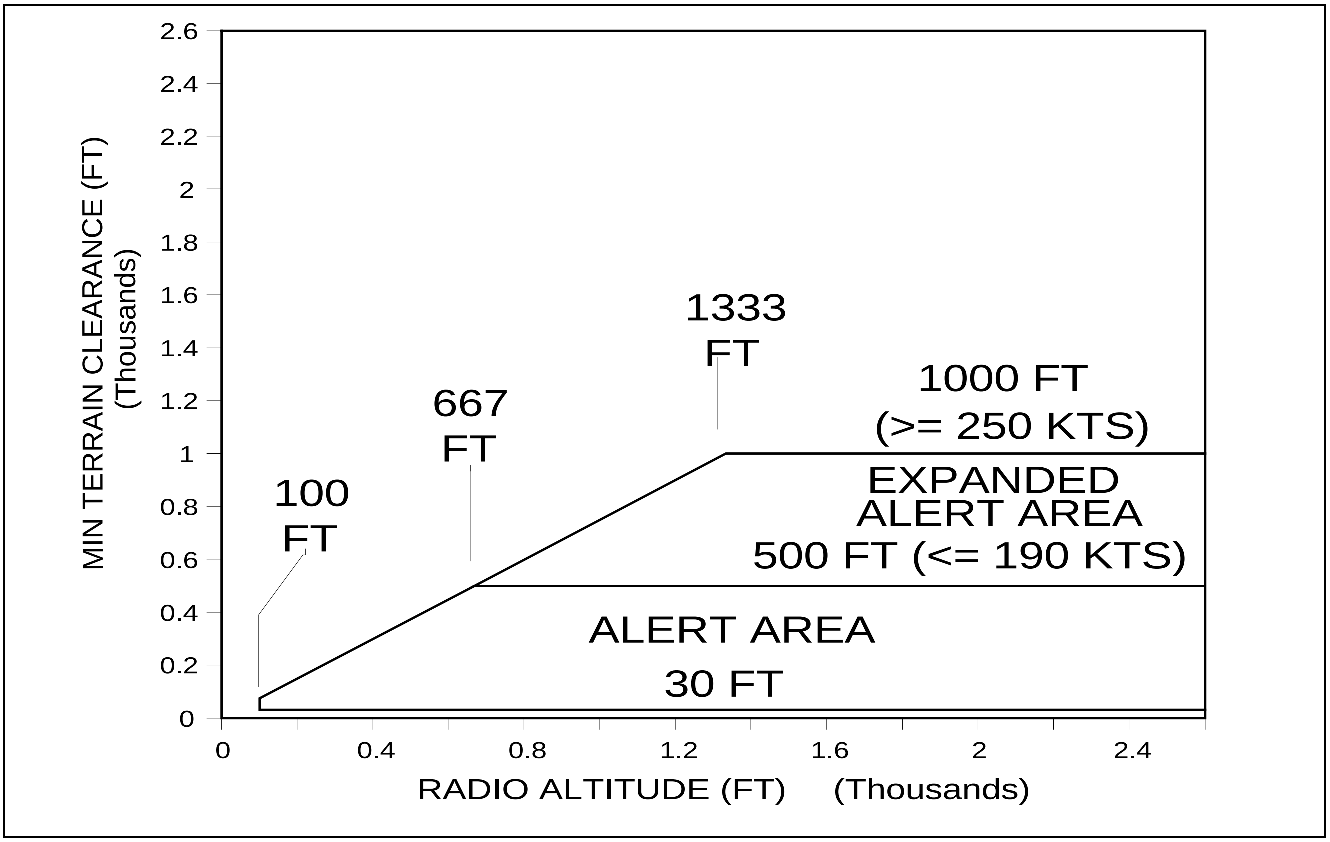


FIGURE 6.2.4.2-3A: MODE 4C STATIC ALERT ENVELOPE (TURBOFAN – MODE 4 TYPE 1)

Mode 4C is based on a minimum terrain clearance, or floor, that increases with radio altitude during takeoff. A value equal to 75% of the current radio altitude is accumulated in a long-term filter that is only allowed to increase in value. If the radio altitude should later decrease, the filter will store its maximum attained value. Further decrease of radio altitude below the stored filter value with gear or flaps up will result in the warning “Too Low Terrain”.

A simplified example will illustrate this operation. First assume the radio altitude increases rapidly from zero feet to 400 feet. The filter will begin charging to 75% of 400 feet, or 300 feet. In 20 seconds, the filter will have charged up to approximately 220 feet. Now if the radio altitude decreases so that 75% of this value results in something less than 220 feet (i.e., approximately 295 feet or less), the filter remains at a value of 220 feet. Further reductions in radio altitude below 220 feet will result in the “Too Low Terrain” warning.

This warning is provided to prevent inadvertent controlled flight into the ground during takeoff climb into terrain that produces insufficient closure rate for a Mode 2 alert. After takeoff, and change over from takeoff to cruise or approach, the Mode 4A and 4B will provide this protection.

A ratchet function is applied to the Mode 4C voice warning which is equivalent to the ratcheting voice message described above. Once the message is given, the envelope is biased down by 20% and further alerts are held off until this additional 20% radio altitude is lost. The caution/warning lamps are not affected and will remain on until the terrain clearance problem is rectified.

Figures 6.2.4.2-4 (turboprop) and 6.2.4.2-4A (turbofan) shows the effective Mode 4C alert protection for a typical takeoff scenario. This takeoff profile matches the scenario described for the dynamic envelopes of Mode 3 (Figure 6.2.3-3). The vertical axis indicates terrain clearance at the point of warning and the horizontal axis indicates time after takeoff. The envelope is cut off at the bottom as described above, and is cut off at the top due to floor limiting at the corresponding Mode 4A boundary. The aircraft flight profile for this scenario is included for reference.

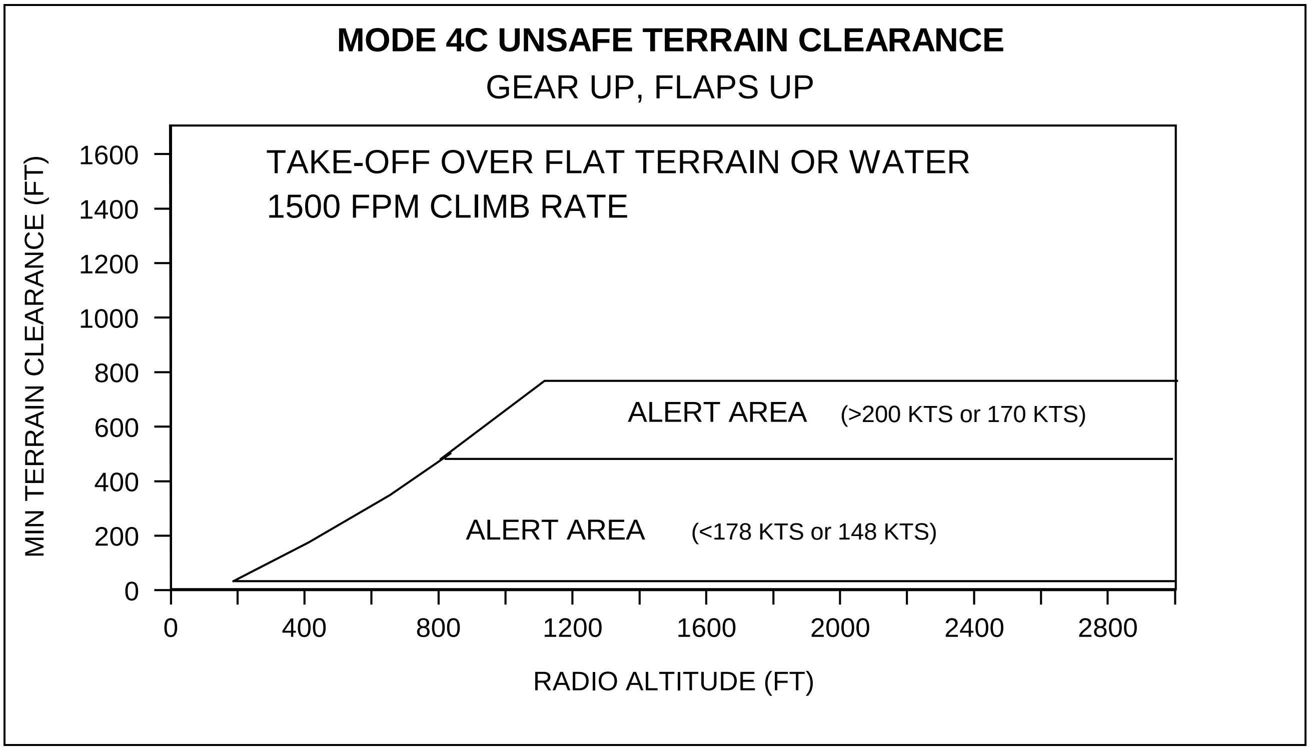


FIGURE 6.2.4.2-4: MODE 4C DYNAMIC ALERT BOUNDARY (TURBOPROP)

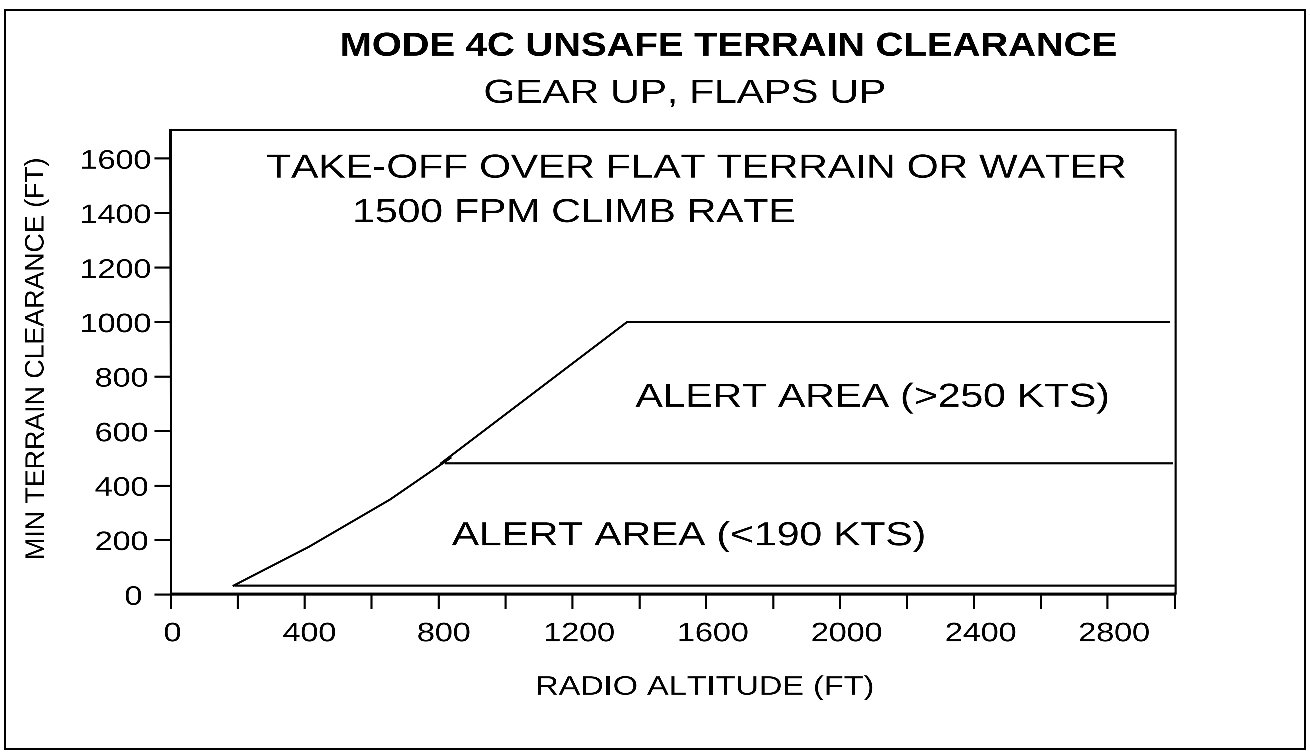


FIGURE 6.2.4.2-4A: MODE 4C DYNAMIC ALERT BOUNDARY (TURBOFAN)

6.2.5 Mode 5 -- Descent Below Glideslope

Mode 5 provides two levels of alert when the aircraft flight path descends below the glideslope beam on front course ILS approaches. Figure 6.2.5-1 is a functional block diagram description of Mode 5. A delay of approximately 0.8 seconds is inserted between the alert output and the enabling logic during an alert condition to help prevent nuisance alerts.

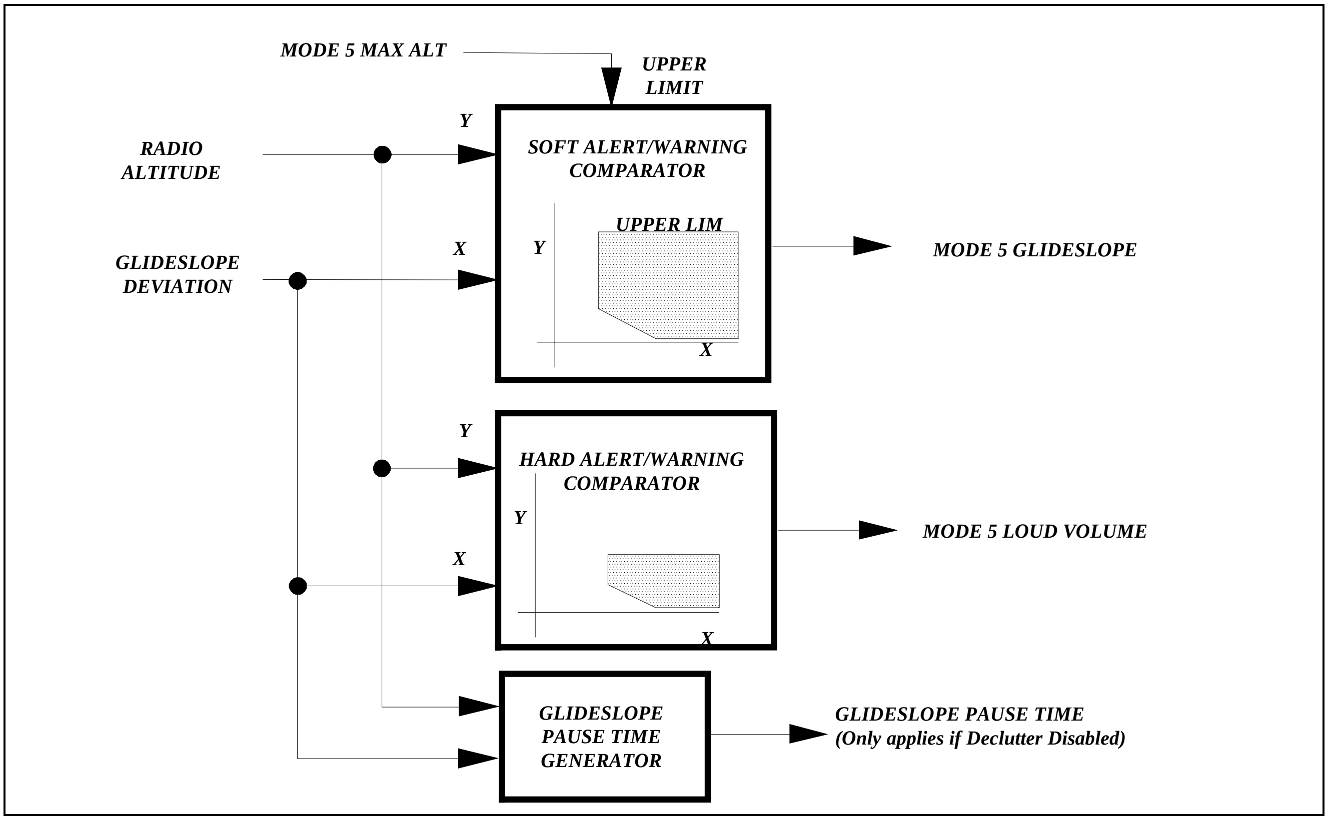


FIGURE 6.2.5-1 MODE 5 FUNCTIONAL BLOCK DIAGRAM

Logic is provided which suppresses the aural alert after one message has been given. Follow-on alerts are only allowed when the aircraft descends lower on the glideslope beam by approximately 20%. Note that this is NOT a 20% radio altitude change, but 20% of the current Mode 5 curve (as if the whole curve was shifted 20% to the right). For example, at 500 feet the curve is 1.3 dots, so the next alert would occur at 1.56 dots. The caution lamps remain on until the excessive “Fly-Up” condition has been corrected. Once the aircraft exceeds 2 dots “Fly-Up” below 300 feet the aural alert changes to a loud double glideslope followed by a 3-second pause. This will be repeated approximately every 5 seconds.

Additionally, Mode 5 “Glideslope” alerts can occur during penetration of the Mode 1 outer envelope while the Mode 1 “Sinkrate” audio is suppressed.

Figure 6.2.5-2 displays the static envelope for the first alert boundary. The dynamic case does not differ significantly from the static envelope, and therefore is not illustrated. The maximum upper limit of 1000 feet nominal allows capture of the beam before enabling this Mode. Higher upper limits are used at certain airports to improve alert/warning envelope protection (via envelope modulation). Deviation boundaries are shown in “dots” below the beam (i.e., Fly Up) where one dot equals 0.0875 DDM. The first alert activation occurs whenever the aircraft is more than 1.3 dots below the beam and is called a “soft” glideslope alert because the volume level of the “Glideslope” audio warning is approximately one half (-6 dB) that of the other alerts.

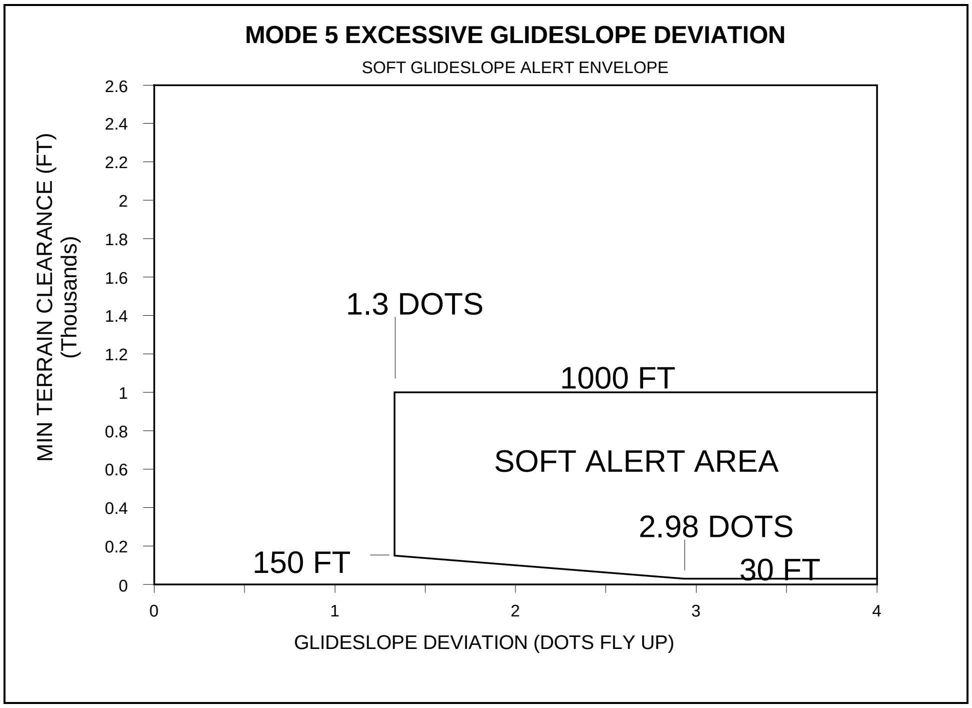


FIGURE 6.2.5-2 MODE 5 STATIC SOFT ALERT ENVELOPE

A second alert boundary (Figure 6.2.5-3) occurs below 300 feet radio altitude with greater than 2 dots deviation and is called "loud" or "hard" glideslope alert because the volume level is increased to that of the other alerts.

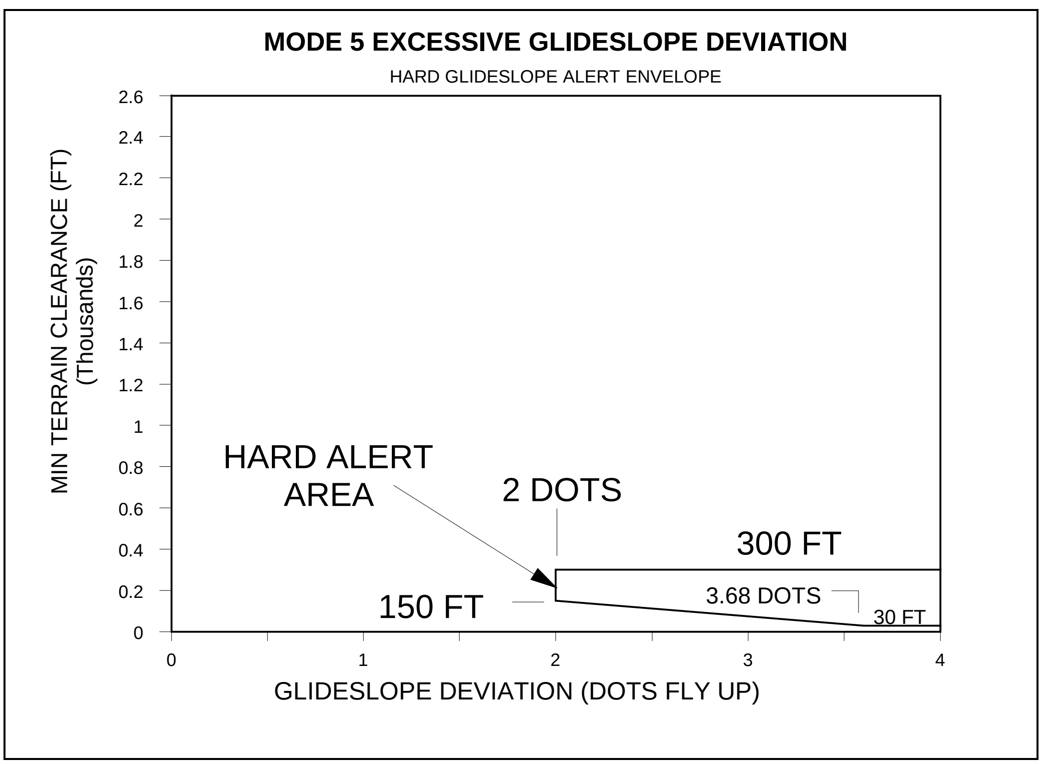


FIGURE 6.2.5-3 MODE 5 STATIC HARD ALERT ENVELOPE

Both envelopes allow additional deviation below 150 feet of radio altitude to allow for normal beam variations near the threshold. This is shown in the envelope of Figure 6.2.5-2 as the sloped portion of the curve, where the equation relating radio altitude and glideslope deviation required for the soft alert is:

$$\text{MIN TERRAIN CLEARANCE (FT)} = 243 - 71.43 \bullet \textit{GLIDESLOPE DEVN}(\textit{DOTS FLY UP})$$

and in Figure 6.2.5-3 for the hard alert:

$$\text{MIN TERRAIN CLEARANCE (FT)} = 293 - 71.43 \bullet \textit{GLIDESLOPE DEVN}(\textit{DOTS FLY UP})$$

<u>Figure 6.2.5-4 shows the enable/disable conditions for Mode 5.</u> All of the following items must be true for Mode 5 to be active:

1) Valid radio altitude and glideslope inputs must be present (ILS Tuned and glideslope data valid).

2) An ILS front course has been established. To prevent Mode 5 nuisance alerts due to false fly up lobes during backcourse approaches an external backcourse Inhibit is provided by a discrete glideslope inhibit input.

3) The system must be either in approach mode (see section 5.13), or landing flaps have been selected to prevent possible nuisance alerts during takeoff, before the landing gear is retracted

4) Landing gear must be down. At certain airports this gear down requirement is overridden, see the envelope modulation description in section 6.8. Landing gear status is equated to landing flaps status on fixed gear aircraft.

5) The pilot has not selected glideslope cancel. This is an optional cockpit mounted switch, typically part of the glideslope Lamp assembly. The glideslope cancel switch is configured to operate as follows: the “Glideslope” alert can be manually canceled by the crew by momentarily activating the glideslope cancel discrete any time below 2000 feet nominal radio altitude if the ILS is tuned. The cancel can be reset by ascent above 2000 feet nominal, or descent below 30 feet. The cancel can also be reset by selection of a non-ILS frequency.

The state of the glideslope cancel selection is always retained during loss of system power.

Numerous complaints of unwanted glideslope alerts while capturing the localizer have been received from operators. These unwanted alerts typically occur while laterally capturing the localizer below 1000 feet, and during straight and level flight intercepts of the localizer. In both cases localizer capture is occurring inside the outer marker.

6) The MKVI/MKVIII EGPWS will generally not receive a localizer input. In those cases where it does, it can be used to solve the lateral capture problem. When above 500 feet AGL, glideslope alerts are only enabled if the Localizer is within ±2 dots. This reduces nuisance alerts when initially capturing ILS. Below 500 feet the Localizer requirement is overridden. Envelope modulation can raise the 500-foot level such that it is 500 feet below the modulated Mode 5 limit. For installations without localizer, the glideslope alerts are enabled.

7) To solve the level flight intercept problem, the upper altitude limit for the glideslope alert is modulated with vertical speed. For normal descent rates above 500 FPM, the upper limit is maintained at the normal 1000-foot level. This is then linearly reduced to a bottom limit of 500 feet for level flight or climb rates. For a level flight intercept of the localizer no glideslope alert would be possible until 500 feet AGL was reached. In all cases if altitude rate is not valid then the nominal 1000-foot AGL Mode 5 enable altitude is used. Note that this change also has the additional benefit of shutting off the glideslope alert when the pilot corrects his flight path back up towards the glideslope after receiving an alert. In addition the altitude limits are raised with envelope modulation as detailed above.

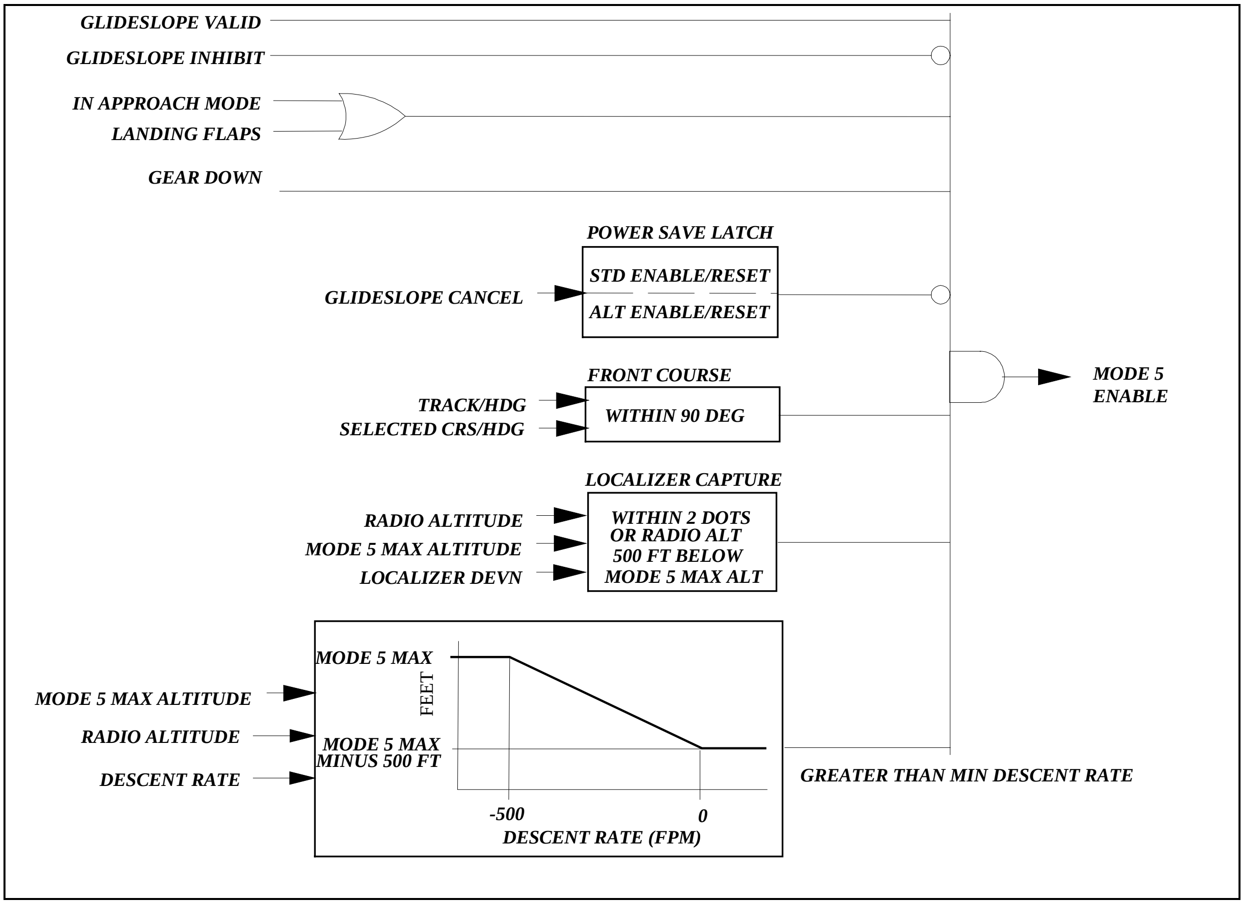


FIGURE 6.2.5-4: MODE 5 ENABLE

6.3 Terrain Clearance Floor

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial release and entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General document.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003

The Terrain Clearance Floor (TCF) alert function adds an additional element of protection to the standard Ground Proximity Warning System. It creates an increasing terrain clearance envelope around the airport runway to provide CFIT protection against situations where Mode 4 provides limited or no protection. TCF alerts are based on current aircraft location from GPS, destination runway center point position (from the terrain database) and radio altitude. TCF is active during takeoff, cruise and final approach. This alert mode complements the existing Mode 4 protection by providing an alert based on insufficient terrain clearance even when in landing configuration. Alerts for TCF illuminate GPWS cockpit lamps and produce aural messages.

The TCF function has been enhanced with a Runway Field Clearance Floor (RFCF) alert function based on current aircraft location, destination runway center point position and height (MSL, not AGL) above destination runway.

When an aircraft penetrates either the TCF or the RFCF alert envelope the aural message *"Too Low Terrain"* will occur.

This aural message will occur once when initial envelope penetration occurs, and one time thereafter for each 20% degradation in either altitude (AGL) or altitude (MSL) depending on which envelope was violated (TCF or RFCF respectively). At the same time the appropriate GPWS alert lamps will illuminate. The lamps will remain on until the alert envelope is exited.

6.3.1 TCF System Requirements

6.3.1.1 System Inputs

Table 6.3.1.1-1 lists the inputs and internal database items used with the TCF/RFCF function:

TABLE 6.3.1.1-1: TCF INPUTS

Parameter	Source of Data
Radio Altitude	External: Radio Altimeter (AGL)
Altitude	External: Geometric Altitude (MSL)
Latitude	External or Internal: GPS
Longitude	External or Internal: GPS
FMS/IRS Update Discrete	External for inertial based position
Runway Center Latitude	Internal: Database
Runway Center Longitude	Internal: Database
Runway Elevation	Internal: Database
Alert Envelope Parameters	Internal: Database
1/2 Runway Length	Internal: Database
System Error Factor	Internal: Database

6.3.1.2 Runway Database

The runway database consists of data records containing the position of airport runway center points along with 1/2 the runway length. The database includes all runways in the region(s) loaded greater than or equal to 2000 feet in length. The process of generating this database will be certified and will include an end check that validates that the data was not corrupted in the translation process. This database can be updated without affecting the customer certified system part number.

The design of the database and related software is such that additional runway records can be added in the future without altering code. The database provides a means of accessing the records of runways closest to the current aircraft position.

6.3.1.3 Alert Envelopes

The TCF alert envelope is a circular band centered over the selected runway. Figures 6.3.1.3-1 and 6.3.1.3-2 illustrate the shape of the TCF alert envelope.

FIGURE 6.3.1.3-1: TCF ALERT ENVELOPE COMPONENTS

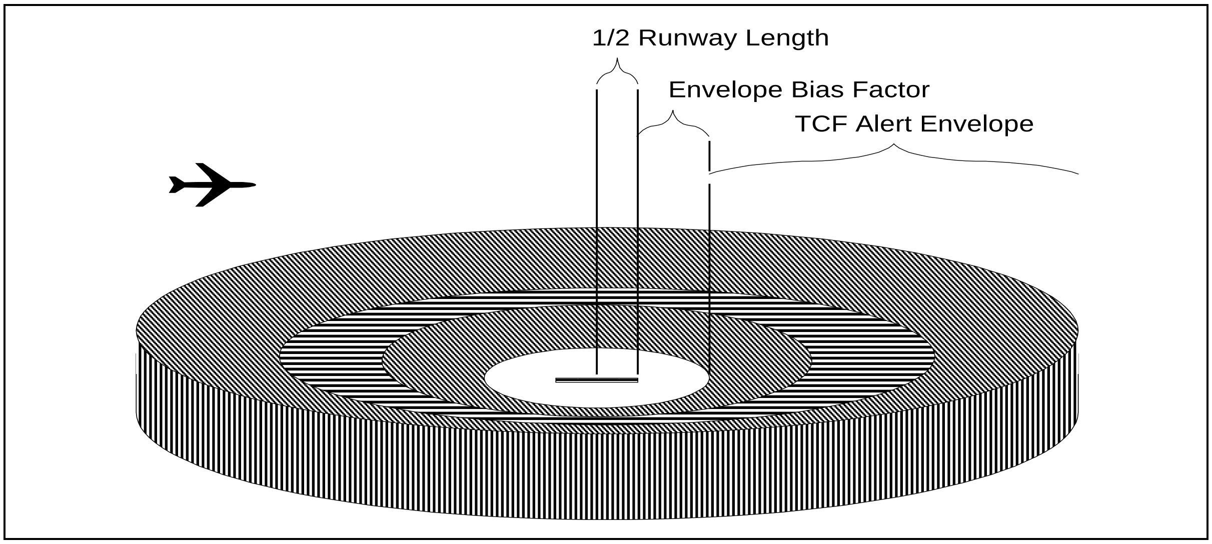
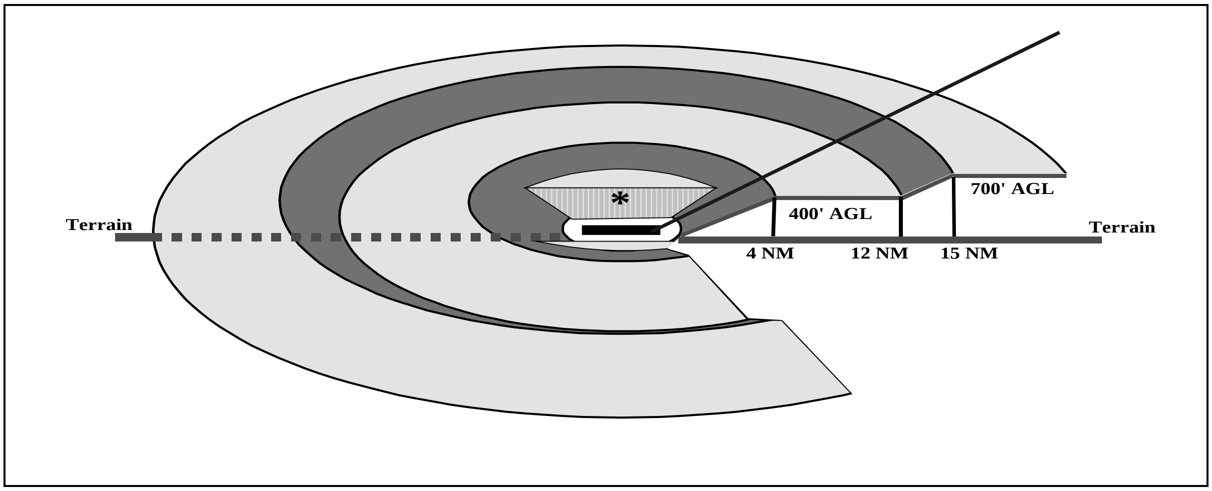


FIGURE 6.3.1.3-2: TCF ALERT ENVELOPE CUT-AWAY VIEW



The distance from the runway center to the inner envelope edge is equal to 1/2 the runway length plus the envelope bias factor. Thus the inner radius of the envelope is modulated based on the runway length and an envelope bias factor (k). Runway length will vary from one runway to the next, and the envelope bias factor is typically 0.35 nm to 1 nm (varying with position accuracy). Figure 6.3.1.3-2 illustrates a cutaway “slice” of the alert envelope. The outer alert envelope boundary extends to infinity, or until it meets the outer alert envelope boundary of another runway.

The TCF curve is limited to a minimum value of 245 feet when it is determined that the aircraft is to the side of the runway. This is shown in the central portion of Figure 6.3.1.3-2 and as a shaded area in Figures 6.3.1.3-3 and 6.3.1.3-4. This feature provides improved alerting when landing to the side of the runway.

Figure 6.3.1.3-5 is a view of the TCF protection area when aligned with the runway.

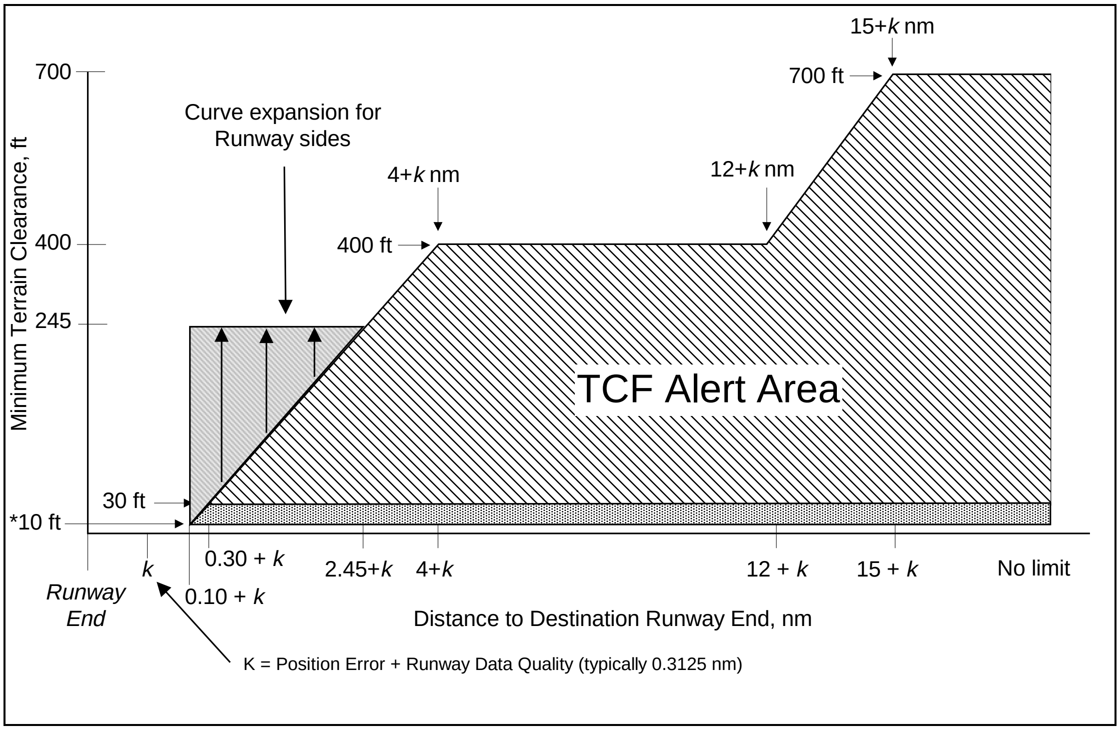


FIGURE 6.3.1.3-3: TCF ALERT CURVE

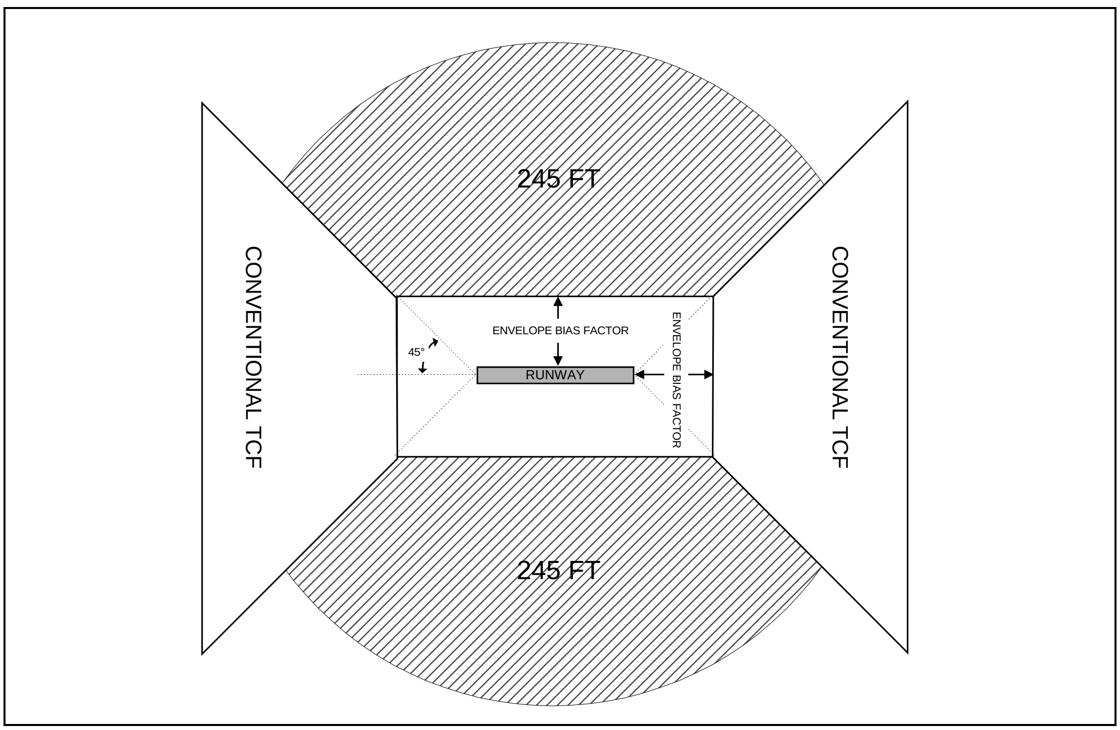


FIG-6.3.1.3-4: PLAN VIEW OF EXPANDED TCF ALERT AREA

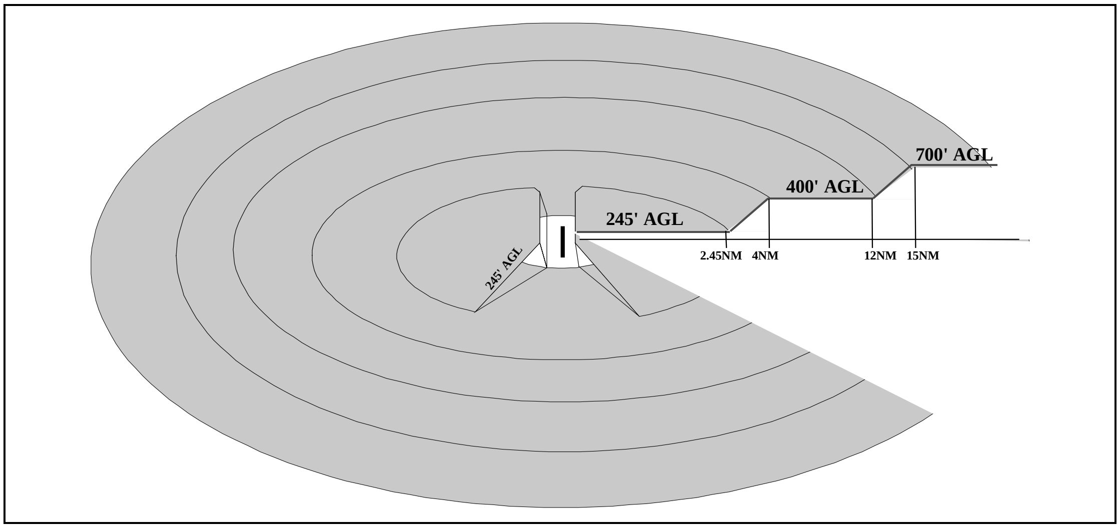


FIG-6.3.1.3-5: TCF ALERT AREA VIEWED ALONG RUNWAY TRACK

The Runway Field Clearance Floor (RFCF) alert envelope is a circular band centered over the selected runway but unlike the radio altitude based TCF envelope, the RFCF envelope only extends 5 NM past the end of the runway. The bias factor (where the protection starts) is equal to the TCF bias factor (k) plus an additional offset proportional to the Geometric Altitude Figure Of Merit (FOM). Figure 6.3.1.3-6 illustrates the shape of the alert envelope. This feature provides improved alerting for cases where the runway is at a high elevation compared to the terrain below the approach path. In these cases the radio altitude may be large enough to inhibit normal TCF operation, but the aircraft could actually be below the runway elevation.

Field clearance (height above runway) is determined by subtracting the elevation of the selected destination runway from the current altitude (MSL).

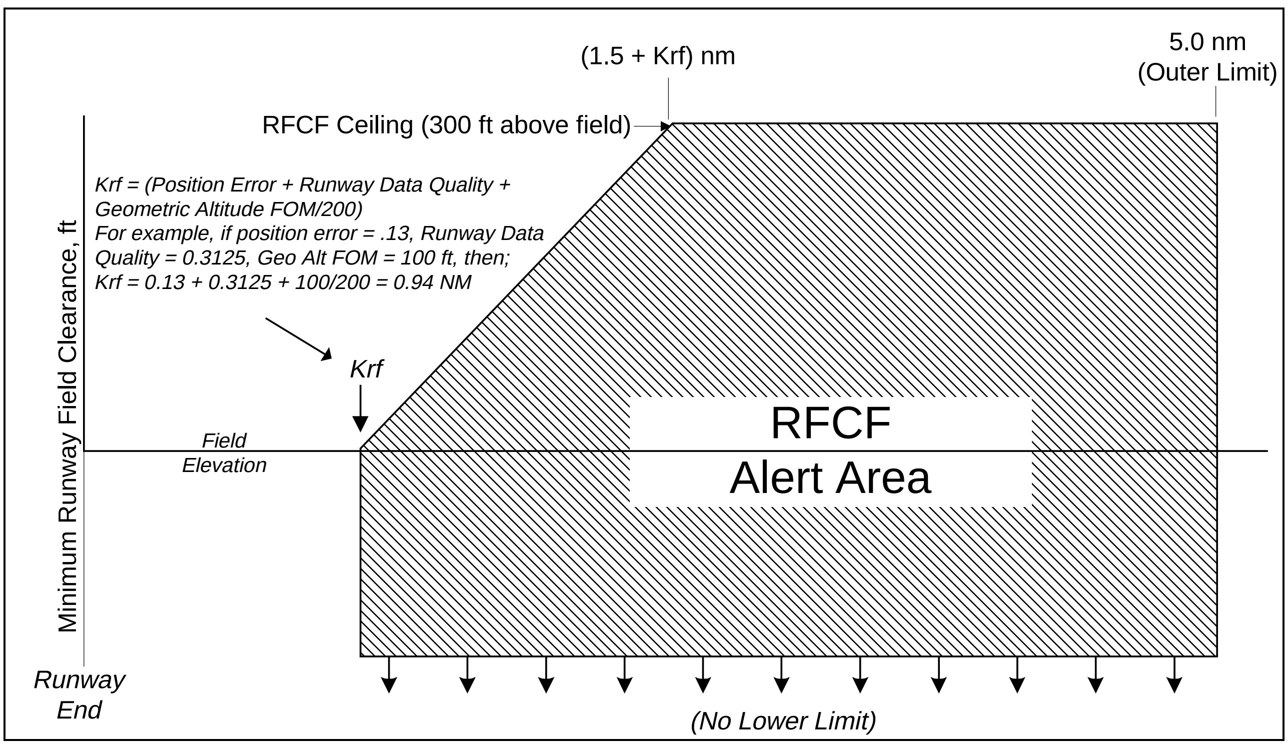


FIGURE 6.3.1.3-6: RFCF ALERT AREA

6.4 Advisory Alerts

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial release and entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
18-AUG-00 - MJC	6.4.3: Added Glideslope Cancel to the list of conditions to activate the Smart Callout (this has always been the case – document ommision only).	-	-
11-JUN-01 – P. Bateman	SCR 5919: Table 6.4.1: Added Above Field Callout.	-008	-008
11-JUN-01 – P. Bateman	SCR 5991: Addition of autopilot engaged bizjet bank angle curve.	-008	-008
02-JUL-01 – S. Wright	Added review comments.	-008	-008
30-JAN-02 – N Paterson	Document only change. Added Autopilot note in 6.4.4.	-	-

The configuration module configuration logic selects a pre-defined set of Mode 6 Callouts. These callouts include altitude awareness and minimums type callouts. The selected menu will annunciate during the cockpit initiated long self-test sequence. Selection of menus which are not defined will set Mode 6 INOP to activate system monitor(s). The following table identifies all of the Mode 6 Callouts that are available.

TABLE 6.4.1: MODE 6 CALLOUTS

CALLOUT	DESCRIPTION
MINIMUMS-MINIMUMS	PROVIDES “MINIMUMS MINIMUMS” CALLOUT FOR DESCENT BELOW MINIMUMS SETTING
SMART CALLOUT	PROVIDES “FIVE HUNDRED” CALLOUT FOR DESCENT BELOW 500 FEET, ONLY GIVEN DURING NON-PRECISION APPROACH
ABOVE FIELD CALL-OUT	PROVIDES “FIVE HUNDRED” OR “FIVE HUNDRED ABOVE” CALL-OUT FOR DESCENT BELOW 500 FEET ABOVE RUNWAY ELEVATION.
200	PROVIDES “TWO HUNDRED” CALLOUT FOR DESCENT BELOW 200 FEET
100	PROVIDES “ONE HUNDRED” CALLOUT FOR DESCENT BELOW 100 FEET
50	PROVIDES “FIFTY” CALLOUT FOR DESCENT BELOW 50 FEET
40	PROVIDES “FORTY” CALLOUT FOR DESCENT BELOW 40 FEET
30	PROVIDES “THIRTY” CALLOUT FOR DESCENT BELOW 30 FEET
20	PROVIDES “TWENTY” CALLOUT FOR DESCENT BELOW 20 FEET
10	PROVIDES “TEN” CALLOUT FOR DESCENT BELOW 10 FEET

Only aural annunciations are available for this mode. However, callout messages are encoded on ARINC 429 discrete output labels.

The available Mode 6 Callout menus are listed in section 5.3.4 of the MKVI/MKVIII EGPWS Installation Design Guide.

Refer to section 6.4.1 for information on the Minimums-Minimums callout functionality.

Refer to section 6.4.2 for information on the Altitude Callout functionality.

Refer to section 6.4.3 for information on how the Smart “500” Callout is enabled.

Refer to section 6.4.4 for information on the Bank Angle callout functionality.

Refer to section 6.4.5 for information on the Above Field callout functionality.

6.4.1 Minimums Type Callouts

For this callout type, only the basic “Minimums-Minimums” callout is available from the MKVI/MKVIII EGPWS.

The minimums type callouts are given when transitioning the minimums setting with the landing gear down. The minimums call-out is triggered via a DH input that switches to ground. The DH input may be discrete or, available on the MKVIII EGPWS only, ARINC 429 for turbofan aircraft. The computer will only respond to the first transition encountered until a reset term is satisfied.

Other maximum enabling, and reset, altitudes are used at certain airports to increase alerting range. The landing gear logic is also overridden at these airports (see Envelope Modulation section 6.8).

6.4.2 Altitude Callouts

Altitude callout messages are enabled based on the menu set selected. Altitude callouts are only activated between the associated value, and a value 10 feet less than this value (20 feet when above 150 feet). In the event that the callout is not issued in this band, the computer performs as though the callout was given. Only one callout message is active at a time and subsequent callout messages can not be started until the current message completes. In this manner, an effective callout priority is established.

A memory function is utilized to lock out callouts once they have been issued or their associated altitude bands have been transitioned until such time as the altitude becomes greater than 1000 feet in approach mode or the approach mode to takeoff mode transition has occurred.

In the event of program "RESET" (e.g., power interrupts) during the approach phase of flight, the current value of altitude is used to initialize the callout logic such that those callouts above this altitude are treated as though they have already been issued.

To inhibit an altitude callout from occurring at minimums the following lockouts are provided

Callouts 200 feet and above are inhibited if within 30 feet of the minimums setting.

Callouts below 200 feet are inhibited if within +6/-3 feet of the minimums setting.

This lock out is only active as long as the minimums setting and the callout correspond. Therefore, continuous monitoring of this setting is performed.

6.4.3 Smart Altitude Callouts

When enabled the smart callout feature provides for a "500" foot callout that is only active during a non-precision approach. The smart callout feature can function with (or without) any of the normal altitude callouts. If the smart 500 callout is enabled it will be given during an approach if any one or more of the following conditions are true:

1) If the flight path is not within ±2 dots of a valid glideslope beam, or not within ±2 dots of valid localizer if a localizer input is configured.
2) If a backcourse approach is detected.
3) If Glideslope Canel is selected.

The smart callout feature is activated through a configuration module configuration item. In addition altitude callouts must be enabled for the smart callout to function.

6.4.4 Excessive Bank Angle Callout

The bank angle feature provides protection for over banking during maneuvering on approach or climb-out and while at altitude. In addition, it protects against wing or engine strikes close to the runway.

An aural callout consisting of a "Bank Angle, Bank Angle" is given. Follow-on aural messages are only allowed when the aircraft roll angle increases an additional 20% from the previous alert. The bank angle option is enabled through a configuration module configuration item.

The bank angle callout is based on the aircraft's roll angle versus altitude (AGL). Warnings for the MKVI/MKVIII EGPWS are shown in Figure 6.4.4-1 where the roll angle limit varies linearly from 15 degrees at 10 feet AGL, to 50 degrees at 210 feet AGL. A unique bank angle curve is available on the MKVIII EGPWS to be used on turbofan aircraft. The curve is shown in Figure 6.4.4-1A where roll angle limit varies linearly from 10 degrees at 30 feet AGL to 40 degrees at 150 feet AGL.

For airplanes fitted with an autopilot additional protection is provided if the autopilot is engaged. For aircraft configured for the turboprop curve, callouts are also shown in Figure 6.4.4-1 where the roll angle limit varies linearly from 15 degrees at 10 feet AGL, to 33 degrees at 156 feet AGL. For aircraft configured for the bizjet curve, callouts are also shown in Figure 6.4.4-1A where the roll angle limit varies linearly from 10 degrees at 30 feet AGL, to 33 degrees at 122 feet AGL

Note: Autopilot protection was added in –008. Do not connect an Autopilot Engaged discrete input to dash numbers prior to –008.

When the roll angle exceeds these limits two “Bank Angle” voice messages are given with the standard 0.75 second delay between messages. Once the bank angle messages are given the voice is shut off until the roll angle increased by another 20% at which time another two bank angle messages will be given. If the radio altitude data is invalid (e.g., looses track at high roll attitudes) then the warning threshold is set to the maximum curve value. Figure 6.4.4-1 illustrates the bank angle curves.

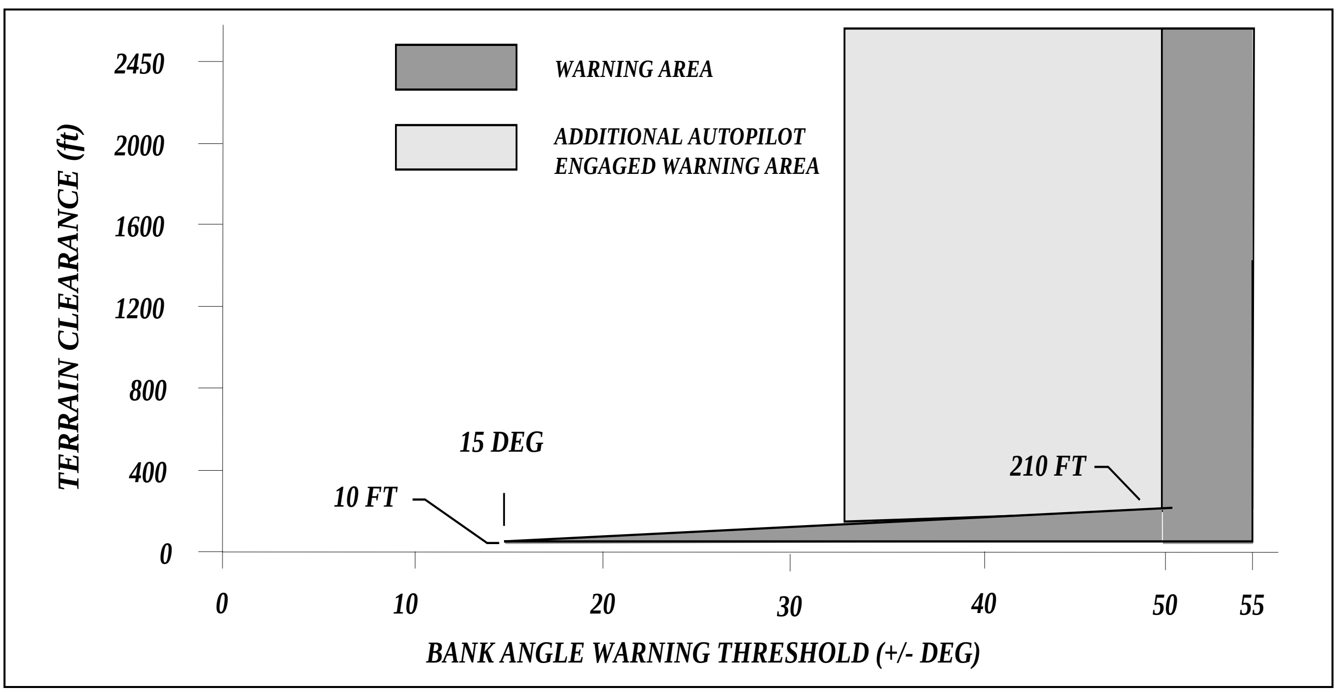
When the roll angle exceeds the curve for altitudes below 210 feet, the .75 second pause is not used, otherwise the two “Bank Angle” voice messages are given with the standard 0.75 second delay between messages. Once the bank angle messages are given, the voice is shut off and the bank angle curve is biased 20% to the right. Only if roll angle then violates this biased curve will another two bank angle messages be given, at which point the bank angle curve will be biased another 20% of nominal to the right. If the roll angle then violates the 40% biased curve, the bank angle messages become continuous with a 3 second pause between sets of messages. The following example illustrates the bank angle callout logic using the 50 degree maximum curve value.

<u>Conditions:</u> (This example applies to a continuous roll past 72 degrees): Aircraft starts banking at cruise altitude. Nominal bank angle threshold set to 50 degrees. As roll angle exceeds 50 +1/-2 degrees, “Bank Angle, Bank Angle” is given once and the callout curve is biased up 20% to 60 degrees. Now as long as the roll angle remains less than 60 degrees no further messages will be given. However, if the roll angle decreases below 50 degrees, and then increases greater than 50 degrees, another “Bank Angle, Bank Angle” is issued and the callout threshold is set to 60 degrees.

If roll angle continues to increase past 60 +1/-2 degrees, “Bank Angle, Bank Angle” is given again and the callout curve will be biased up another 20% of nominal to 72 degrees. Now as long as the roll angle remains less than 72 degrees no further messages will be given. However, if the roll angle decreases below 50 degrees, and then increases greater than 50 degrees, another “Bank Angle, Bank Angle” is issued and the alert threshold is set to 60 degrees.

If roll angle continues to increase past 72 +1/-2 degrees, the continuous voice message with a three second pause between message pairs will start, “Bank Angle, Bank Angle” (3 sec pause) “Bank Angle, Bank Angle” (3 sec pause)..... and so on. However, if the roll angle decreases below 72 degrees the messages will stop. As long as the roll angle remains less than 72 degrees no further messages will be given. If the roll angle then increases to greater than 72 degrees the continuous message will start again. Only if the roll angle decreases below 50 degrees, and then increases greater than 50 degrees, will another “Bank Angle, Bank Angle” be issued and the whole curve biasing logic will start over.

The above example shows the threshold biasing above 210 feet AGL. It is applicable to all altitudes AGL by replacing “50” with the curve value for the current radio altitude. However, the sensitivity of the curve to radio altitude, and radio altitude changes during banking, must be kept in mind when trying to predict the callout thresholds for low level flight.



<u>FIGURE 6.4.4-1: BANK ANGLE CURVE (TURBOPROP)</u>

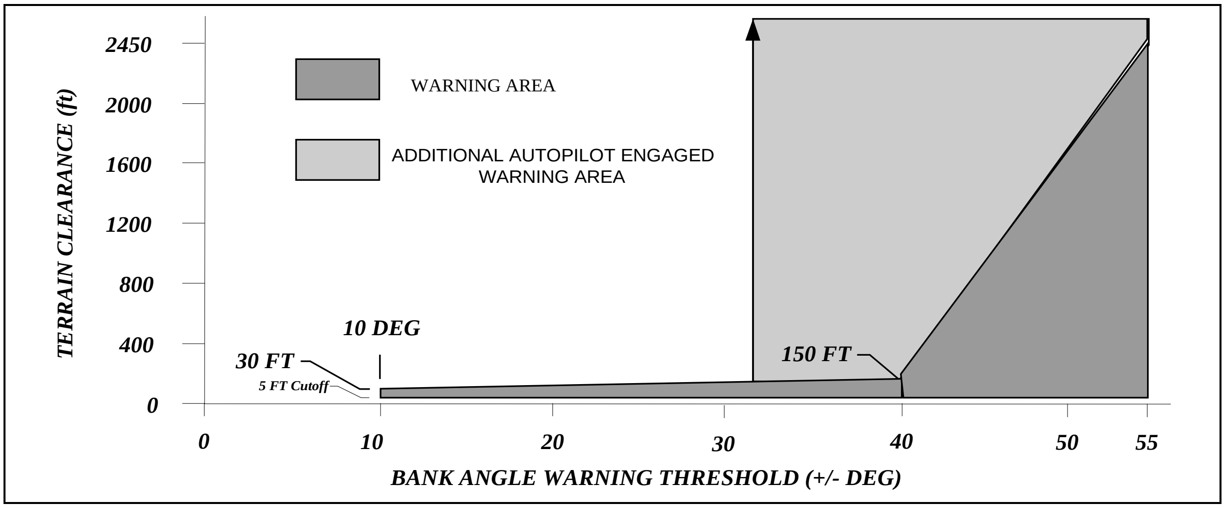


FIGURE 6.4.4-1A: BANK ANGLE CURVE (TURBOFAN)

6.4.5 Above Field Callout

A “500 ABOVE” or “500” callout is provided when the aircraft is within 5 nm’s of a runway and the aircraft is configured for the above field callout.

Geometric altitude and the runway database are used to calculate the height above field and the 500 Above Field Callout is initiated when descending below 550 feet.

Once this condition occurs a power save NVM lockout latch will be set to drive the message request latch. Once set, this lockout latch will inhibit the 500 Above Field Callout from being requested again until a Height Above Runway Field is greater than 700 feet (the next approach or go around). A transition detection on the output state of this latch will drive the voice message request latch.

6.5 MKVIII Windshear Detection Alerts

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial Release and entry into PVCS.	-001	-001
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
02-JUL-01 – S. Wright	SCR 4734: Added Honeywell windshear for BD-100	-008	-008

Windshear detection and annunciation is available for limited aircraft with the Mk VIII EGPWS installed. The status of the windshear function is indicated by a windshear INOP output. Both a discrete lamp driver type output, and an ARINC 429 output bit provide this information. The discrete (lamp driver) output is designed to bias itself on in the event of power loss to the EGPWC.

Windshear Caution disable and Windshear Caution Voice disable options are provided for those installations that disable the windshear caution but preserve the windshear warning.

6.5.1 Honeywell Windshear Detection

Figure 6.5.1-1 presents an overall view of the windshear mode. The IRS/AHRS provides acceleration values along the body axis. These accelerations are transformed to the air mass axis by using body angle of attack (AOA) and are then compared to the atmospheric data from altitude rate and airspeed. The resultant windshear output is gain controlled as a function of altitude, and roll attitude, before producing the detected shear output for the caution/warning logic.

The nominal windshear warning threshold is adjusted, or biased, as a function of numerous conditions. Air mass flight path angle (gamma) is used to bias the threshold, as are abnormal temperature conditions in the atmosphere. In addition, the amount of excess dynamic pressure (Q) is also used to bias the threshold. Aircraft type (currently only the BD-100) is used to select the proper nominal windshear threshold, before the bias values are applied. Windshear enable logic determines the validity, and suitability, of the resultant windshear caution, or warning, that is observed through the output logic.

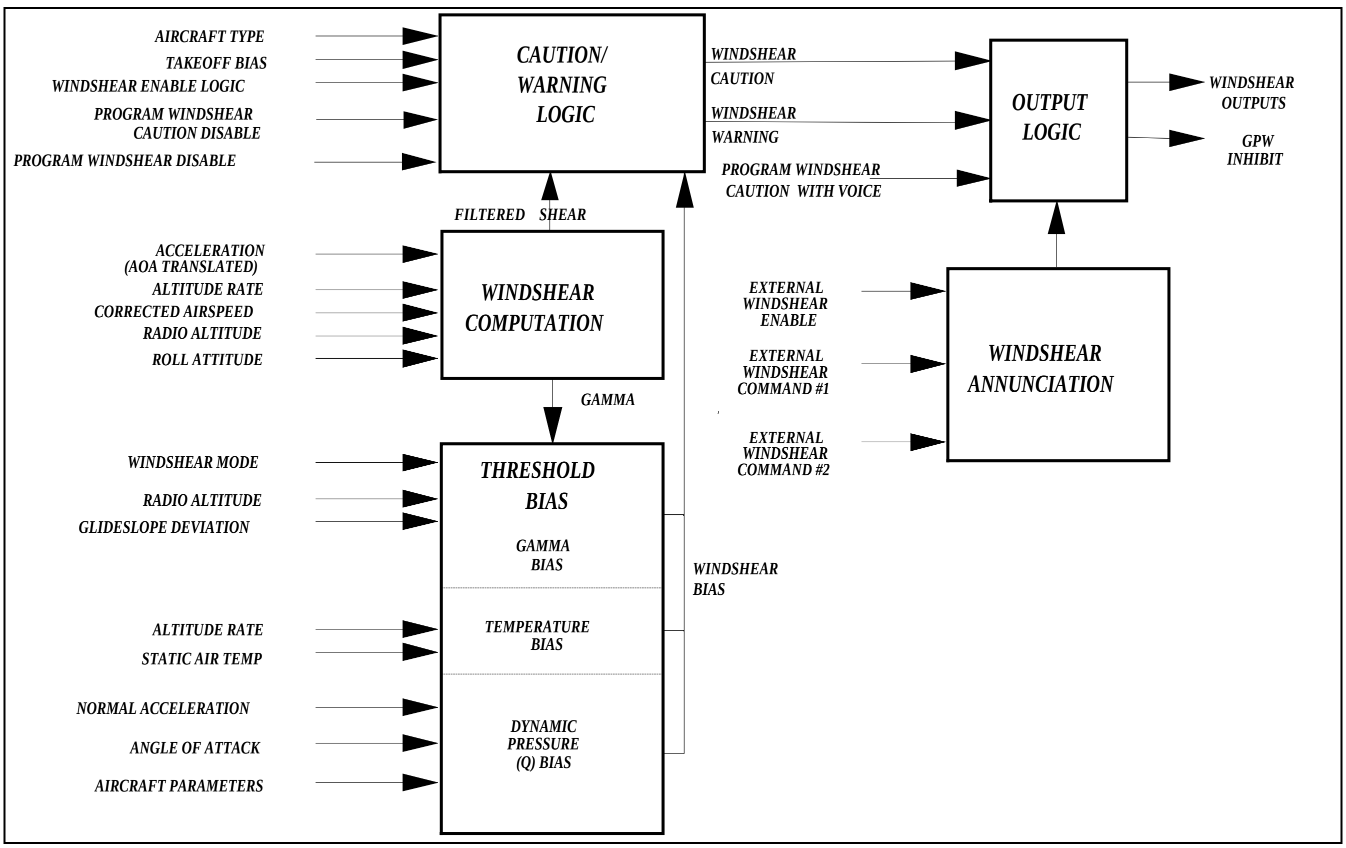


FIGURE 6.5.1-1: WINDSHEAR BLOCK DIAGRAM

The algorithm as shown in figure 6.5.1-2 calculates a total windshear indication and does not resolve individual horizontal and vertical windshear components. The shear signal is modulated by radio altitude and roll angle in order to provide further margin against unwanted alerts that could potentially result from turning into and out of winds.

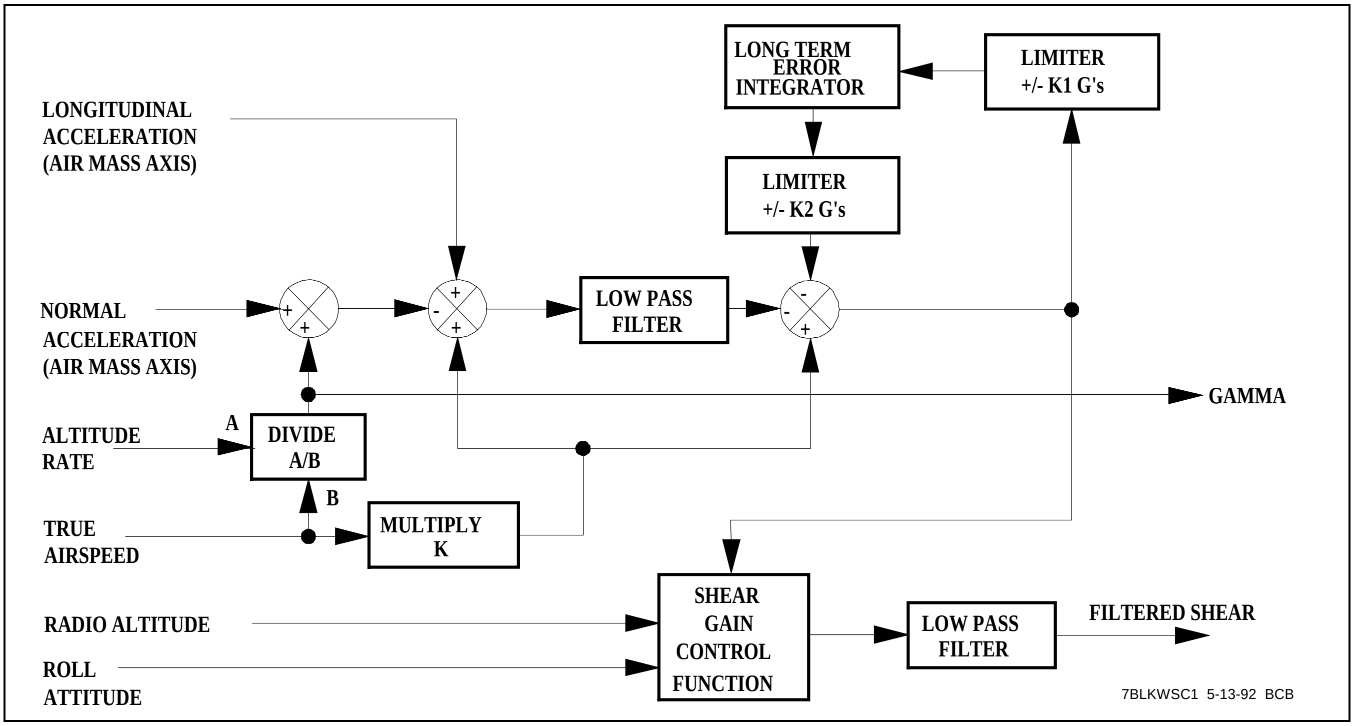


FIGURE 6.5.1-2: WINDSHEAR COMPUTATION DIAGRAM

The shear value is then compared to thresholds that are a function of aircraft type to determine an excessive windshear condition. The thresholds are modulated as a function of static air temperature, excess lift above Vref (during approach), and flight path angle. This modulation provides improved immunity against turbulence-induced nuisance alerts and advanced recognition of microburst windshear events. Figure 6.5.1-3 shows a typical windshear threshold for caution and warnings.

Once the modulated threshold has been exceeded, a siren is sounded, followed by the voice aural “Windshear Windshear Windshear” (or equivalent). This message is given only once, provided the aircraft does not exit and re-enter the windshear detection envelope or the external command is not re-activated after an 8 second lockout.

An output warning lamp is also activated upon exceeding the windshear threshold. This lamp remains on as long as the shear condition exists, or as a minimum, 8 seconds.

The other GPWS modes are inhibited for a minimum of 5 seconds after a windshear warning. These modes may also be inhibited within 60 seconds after a windshear warning through activation of the escape guidance aural inhibit signal. This signal can come from a digital or discrete source.

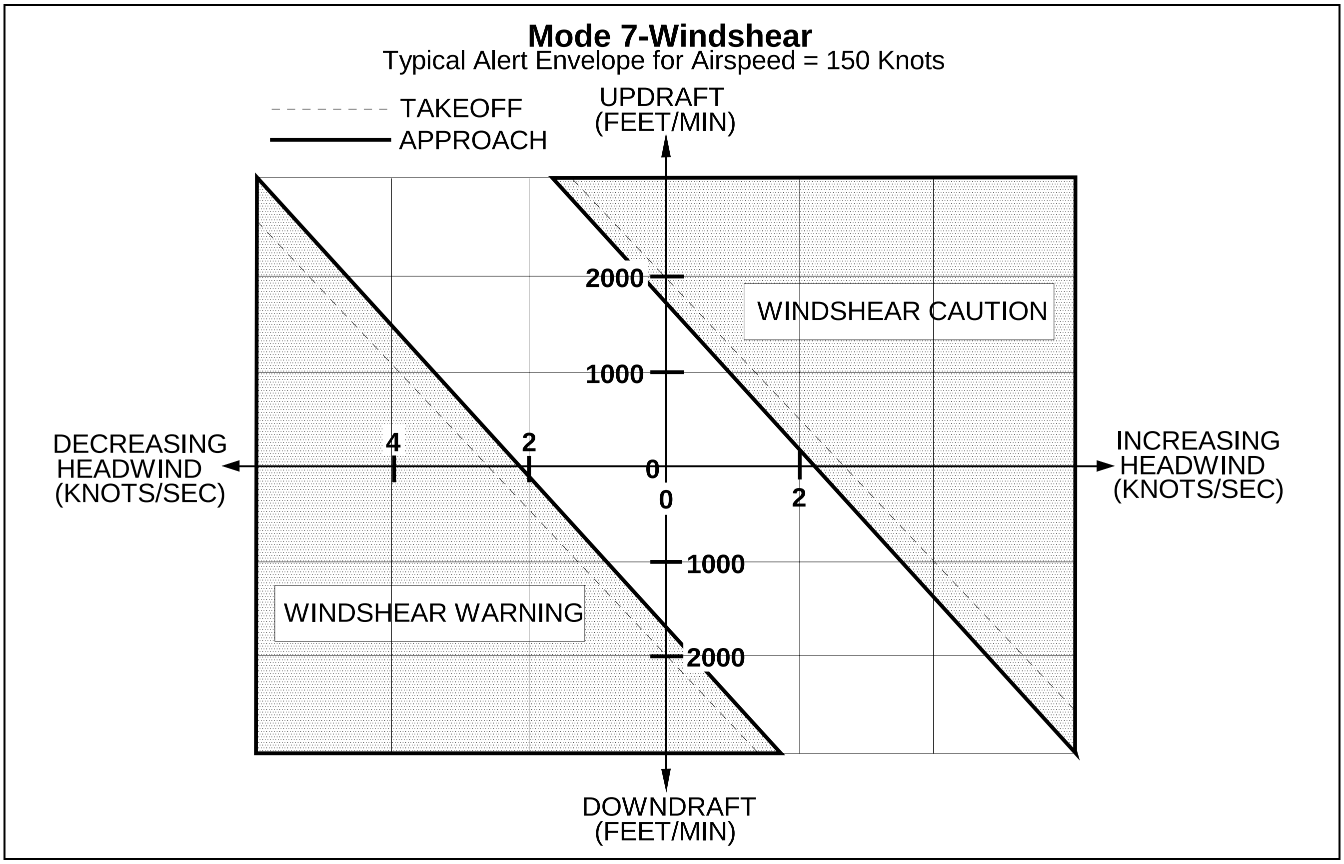


FIGURE 6.5.1-3: TYPICAL WINDSHEAR ALERT THRESHOLDS

Logic is provided to distinguish between the takeoff and approach phases of flight. Slightly different enable logic and gain curves are used for detection in each of these phases of flight as shown in figure 6.5.1-3. The threshold value is also increased by 0.01 g's for the takeoff phase of flight reflecting the lower performance of the aircraft during this phase.

Mode 7 also provides a windshear caution (sometimes referred to as windshear prealert) which can be disabled via a program pin option. This alert is triggered for headwind and updraft conditions that typically exist on the leading edge of a microburst windshear. The same total shear signal is used for the caution as is used for the warning. The threshold magnitude is the same as that used for the windshear detection warning logic, only the polarity is inverted. Threshold modulation as a function of temperature, flight path angle, and lift is not used for the caution.

The windshear caution condition is maintained for a period of at least 8 seconds in order to prevent multiple alerts for a given event due to turbulence. This alert output is disabled when windshear warning conditions prevail. A separate discrete output is activated for this condition. For the basic caution function no voice output is given. However, a program pin option exists to allow for a "Caution Windshear" voice to be given.

6.6 Reserved

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial release and Entry into PVCS.	-001	-001
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003

6.7 Terrain Awareness Functions

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial release and entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4942: General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
02-JUL-01 – S. Wright	Added review comments	-008	-008
30-JAN-02 – N Paterson	SCR 6325: Para 6.7.4 revised MSL to GSL	-010	-010

The Terrain Awareness component of the EGPWS is divided into the functional blocks shown in Figure 6.7-1 with an interface to an optional cockpit display. The highlighted blocks monitor aircraft position with respect to local database-cataloged terrain and provide rapid audio and visual alerts when a terrain threat is detected. Terrain threats are recognized and annunciated when terrain violates specific computed envelope boundaries forward of the aircraft path. The terrain database also includes the obstacle database (see Note) providing similar annunciation when cataloged obstacles violate the same envelope boundaries.

The Terrain Awareness alert lamps and audio outputs behave in the same manner as the standard GPWS mode alerts. Any of the following: Terrain Caution Alert, Terrain Warning Alert, obstacle caution alert or obstacle warning alert will initiate a specific audio alert phrase (see 6.7.4.2 and 6.7.4.3).

Complementing the terrain threat alerts, the EGPWS also maintains a synthetic image of local terrain forward of the aircraft for display on EFIS Navigation Displays (NDs), Multi-Function Displays (MFDs) and Weather Radar Indicators.

The EGPWS may be configured to automatically de-select the weather display and pop-up a display of the terrain threats when they occur. The logic used for these configurable controls also provides an external input for predictive windshear alerts that can override a terrain display and revert to the weather display with the corresponding windshear data.

The EGPWS provides up to two optional external display outputs, each with independent range-scaling control in the same fashion as a weather radar with more than one indicator. Changes of range scaling to one display do not affect the other display. Each of these two independent outputs may be used to drive more than one display.

The blocks in Figure 6.7-1 are described in the following sub-sections. The specific databases, audio output function, and display output processor are described in other related sections of this document.

NOTE: The terrain database may contain obstacle data if available.

6.7.1 EGPWS Input Processing and Signal Selection

The EGPWS input processing and signal selection function conditions and formats aircraft data into proper form for use by the EGPWS while insulating the EGPWS from variations in aircraft type and configuration.

6.7.1.1 Display Configuration

There are several configuration inputs defined as a function of the selected aircraft type. These define the type of display and how it is enabled by the pilot, including (for some cockpit avionics architectures) optional automatic pop-up of the terrain display during Terrain Awareness alerts. Although ARINC-708/708A provides the basic format for the standard radar display bus, there are variations between manufacturers that the EGPWS is designed to handle.

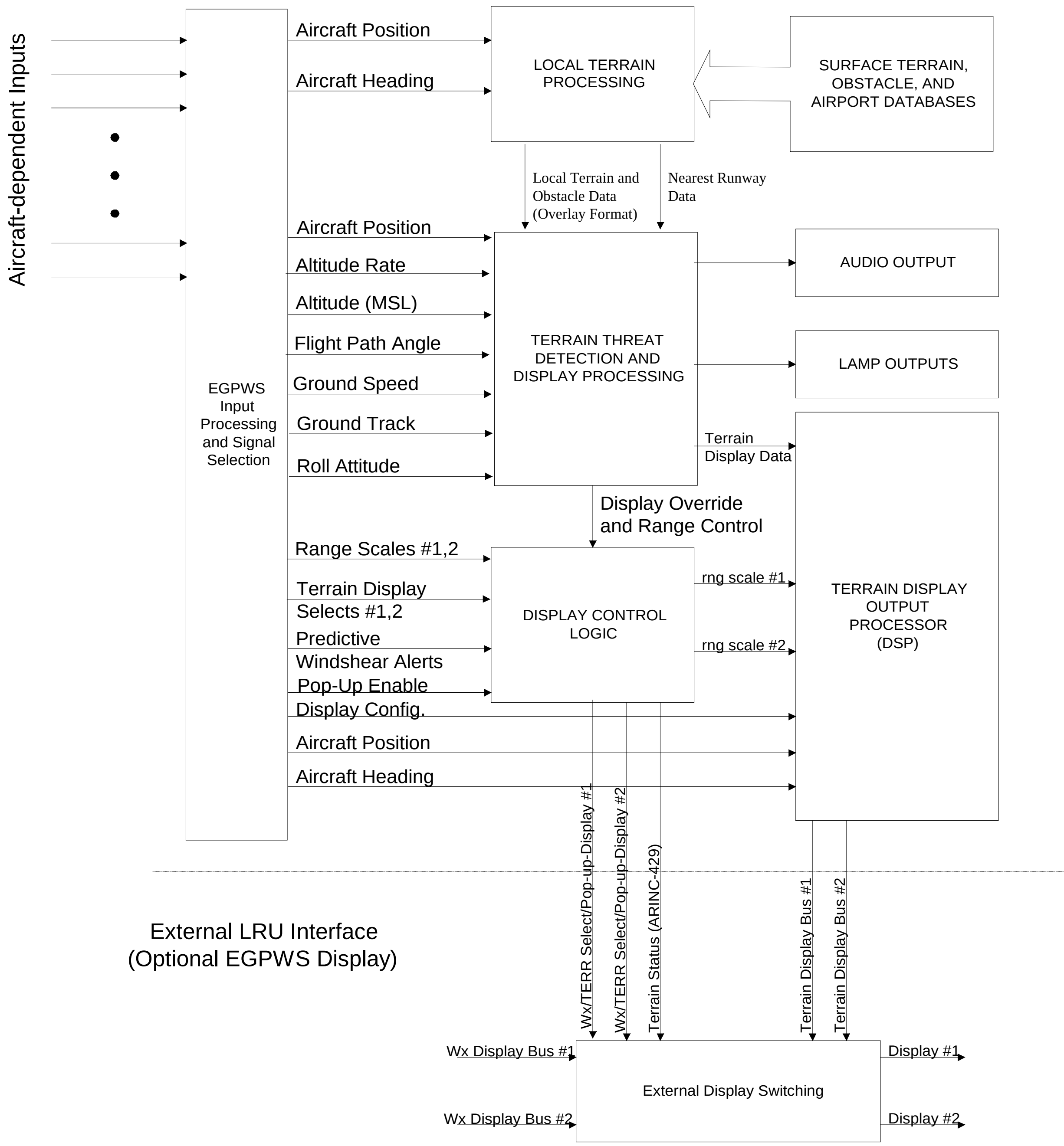


FIGURE 6.7-1: TERRAIN AWARENESS FUNCTIONS

6.7.1.2 Aircraft Data Inputs

Aircraft position latitude and longitude are required for Terrain Awareness operation and are preferably received from an aircraft Global Positioning System (GPS) or an optional internal GPS-PXPRESS card. Refer to section 6.7.10 for more detail on position source selection.

Additionally, aircraft ground track and ground speed data are also received from the GPS.

Aircraft altitude for the Terrain Awareness functions is computed from pressure altitude and SAT received from the Air Data Computer (ADC), altitude from the GPS, and height above ground provided by the computed Geometric Altitude (see section 6.7.8.). Other aircraft inputs include aircraft heading, and flight path angle (gamma, derived by the EGPWC).

6.7.1.3 Control Inputs

Installations provide discrete terrain display select switches in the cockpit for each display. These are momentary contact switches that are processed by the EGPWS input processing and signal selection block as inputs to the Wx/TERR select logic. For some fully integrated displays this selection is provided via a display controller.

In addition a Terrain Inhibit switch may also be provided to deactivate the enhanced functions of the EGPWS.

For some installations, display switching via separate terrain select and weather select switches is supported. If the EFIS is in a proper display mode then pressing the weather select switch will cause weather to be displayed if it is not, and to be deselected (blank image) if weather was already selected. Alternately, pressing the terrain select switch will cause terrain to be displayed if it is not, and to be deselected (blank image) if terrain was already selected.

All installations require input of cockpit-selected range scales for each display. Installations may optionally provide this on single or dual ARINC-429 broadcast buses. Two ARINC-429 buses are provided for ARINC-708/708A split and consolidated control.

6.7.2 Local Terrain Processing

The local terrain processing block extracts and formats local topographic data and terrain features from the related databases creating a set of digital elevation matrix overlays for use by the terrain threat detection and display processing functions. Additionally, data for the nearest runway is also extracted for use by the terrain threat detection and display processing functions. Processing for the topographic and runway database are described in the following sub-sections.

6.7.2.1 Terrain Surface Data

Local terrain processing of topographic surface data updates a set of digital elevation matrix overlays that are positioned with respect to aircraft position. Each matrix element contains the highest terrain altitude with respect to mean sea level in that element’s area. Elements where terrain data are not available are marked invalid.

6.7.2.2 Obstacle Data

In addition to terrain surface data, the terrain database contains obstacle data. The obstacles data is presented on the screen like terrain (same coloring scheme), and cause visual indications for warning and caution alerts like terrain. The current obstacle database is obtained from NOAA, it includes obstacles in the United States and parts of Canada, Mexico and the Bahamas.

Obstacle alerting is activated using the configuration module.

6.7.2.3 Nearest Runway Data

Data for the nearest runway are extracted and processed for use by the terrain threat detection and display processing functions. Data are extracted from the same airport database used by the Terrain Clearance Floor functions (see section 6.3). This database contains data on all runways 2000 feet or more in length with either published endpoint coordinates or adequate information to extrapolate the endpoint coordinates. The contents of the database are processed by the local terrain processing into nearest runway center position, nearest runway threshold position, and nearest runway altitude for use by the EGPWS. These data are updated when the terrain threat detection and display processing functions are performed.

6.7.3 Terrain Threat Detection

The terrain threat detection and display processing block performs the threat analysis on the terrain data within computed caution and warning envelope boundaries below and forward of the aircraft path. Results of these threat assessments are combined with background terrain data and data for the nearest runway and formatted into a terrain display image which can be displayed on a Weather Radar Indicator or an EFIS display in place of the weather image. In the event of terrain caution or warning conditions, a specific audio alert is triggered and the terrain display image is enhanced to highlight each of the types of terrain threats.

During takeoff, terrain cautions and warnings are inhibited by the terrain takeoff guard described in section 6.0.6.

6.7.3.1 Terrain Caution and Warning Envelopes

The basic terrain caution envelope (or yellow alert envelope) and terrain warning envelope (or red alert envelope) boundaries are illustrated in Figure 6.7-2.

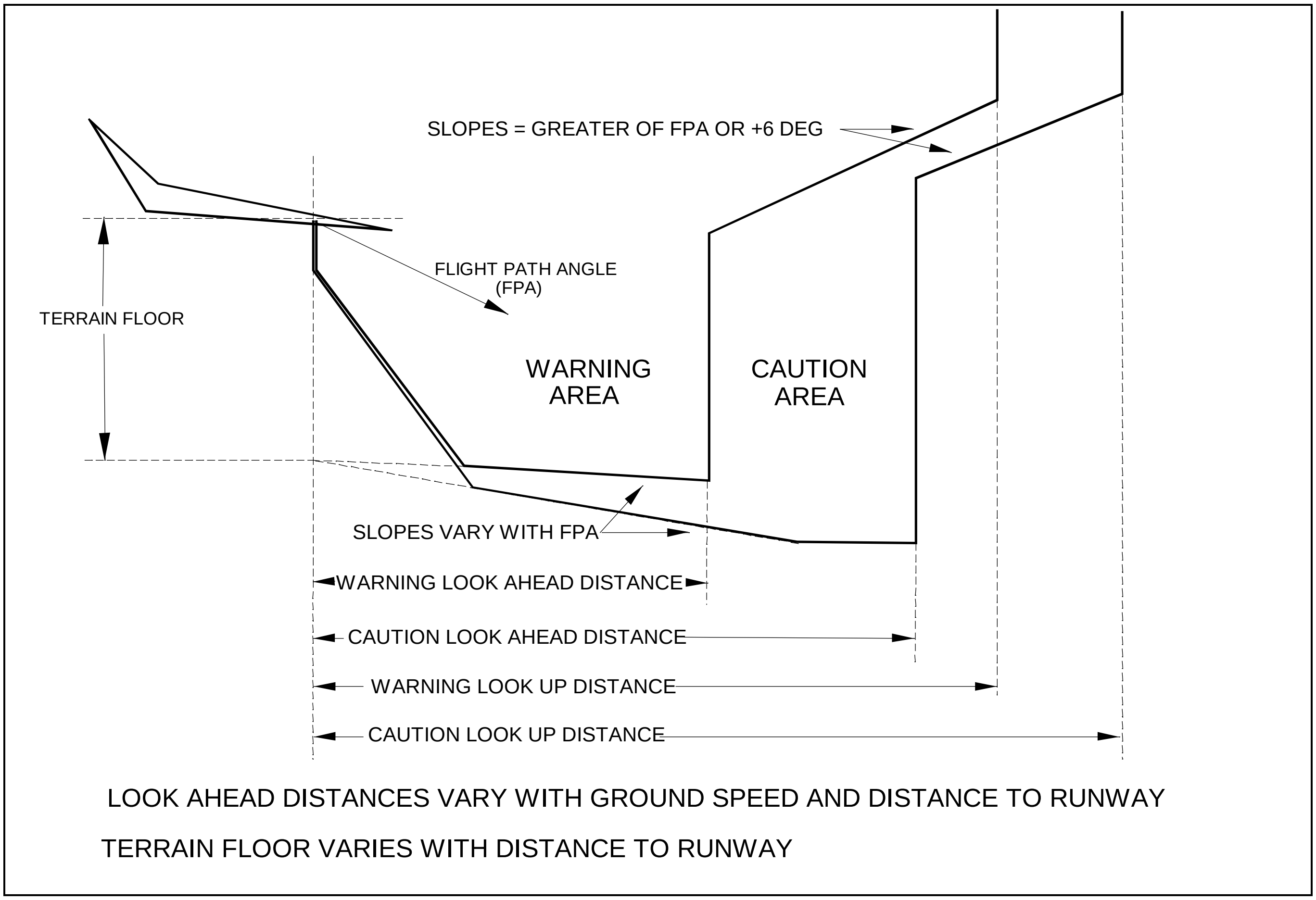


FIGURE 6.7-2: TERRAIN CAUTION AND WARNING ENVELOPE BOUNDARIES

A perspective view of the terrain detection envelope is illustrated in Figure 6.7-3.

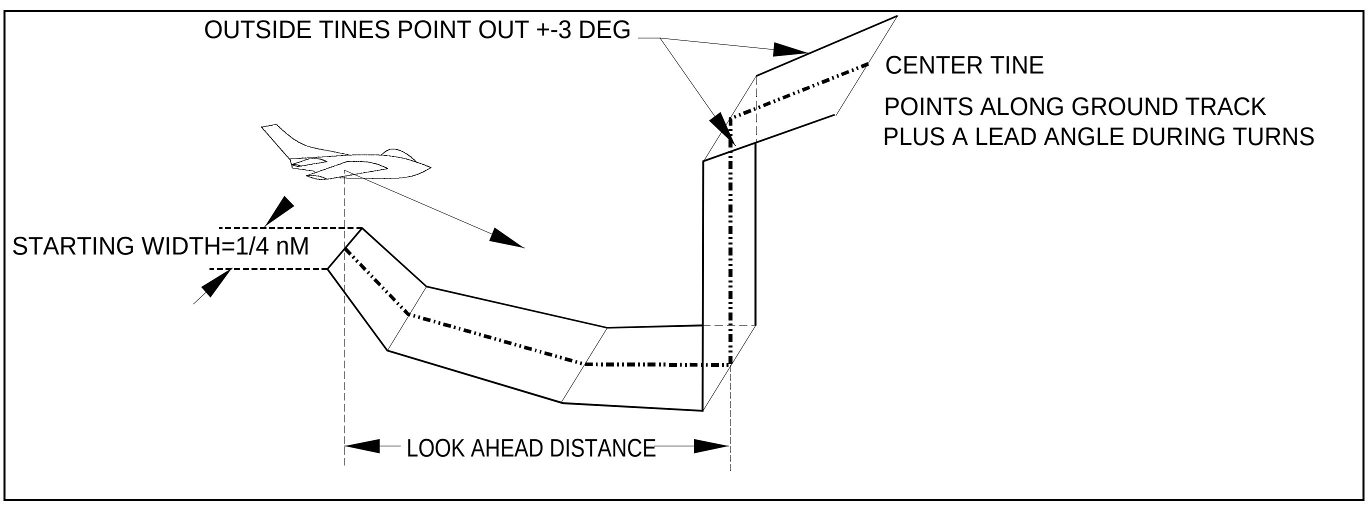


FIGURE 6.7-3: TERRAIN DETECTION ENVELOPE – PERSPECTIVE VIEW

6.7.3.1.1 Caution Altitude Floor

The caution altitude floor (or terrain floor) is computed as a function of aircraft altitude with respect to nearest runway altitude and range to the nearest runway threshold position. This parameter represents a distance below the aircraft. The relationship to the nearest runway threshold location prevents undesired alerts when the aircraft is taking off or landing at an airport. The system is compatible with terrain clearances allowed for by regulatory approach and departure design criteria.

6.7.3.1.2 Caution Look Ahead Distance

The caution look-ahead distance is computed from aircraft ground speed and turn rate to provide an advanced alert with adequate time for the crew to react safely. Depending on the situation this distance roughly corresponds to between 40 and 60 seconds of advance alerting.

6.7.3.1.3 Warning Altitude Floor

The warning altitude floor is set to a fraction of the caution altitude floor, as illustrated in the upper part of Figure 6.7-2. The warning altitude floor is computed as a function of aircraft altitude with respect to nearest runway altitude and range to the nearest runway threshold position. This parameter represents a distance below the aircraft. The relationship to the nearest runway threshold location prevents undesired alerts when the aircraft is taking off or landing at an airport.

6.7.3.1.4 Warning Look Ahead Distance

The warning look ahead distance is a fraction of the caution look ahead distance (computed from aircraft ground speed and turn rate) to provide an advanced warning with adequate time for the crew to react safely.

6.7.4 Terrain/Obstacle Displays and Alerts

The Terrain Awareness alerting and display function maintains a background display of local terrain forward of the aircraft for optional cockpit display. In the event of terrain or obstacle caution or warning conditions, an aural alert and lamp outputs are triggered. The background image is then enhanced to highlight terrain or obstacle threats forward of the aircraft. Obstacle threats forward of the airplane are also enhanced if the adjacent terrain altitude is within a lower terrain layer, or if the adjacent cells are not illuminated. Obstacle enhancement is only applicable to the 15, 30 and 60 arc second tiers

The background terrain is depicted as variable density dot patterns in green, yellow or red. The density and color are a function of how close the terrain or obstacle is relative to aircraft altitude. Additionally, the display of terrain based on absolute terrain elevation is provided if the optional Peaks is enabled. Terrain and obstacle alerts are depicted by painting the threatening terrain as solid yellow or red.

The terrain display algorithms process the set of digital elevation matrix overlays into a matching set of display matrix overlays and passed to the radar display output processor. The display matrix overlays hold display attributes rather than altitude for each matrix element. These attributes are computed for the background and terrain threat areas and kept small (one byte) to reduce memory requirements and transfer time to the radar display output processor. The aircraft position and aircraft heading are used at the radar display output processor to extract the radar-like sweeping image ahead of the aircraft from the display overlays.

Each element of the output display matrix overlays holds a single display attribute byte with fields for the colors, patterns, and symbols shown below in Table 6.7-1.

Color	Terrain Elevation
Solid Red	Terrain threat area – warning.
Solid Yellow	Terrain threat area – caution.
High Density Red Dots	Terrain more than 2000 feet above aircraft altitude.
High Density Yellow Dots	Terrain between 1000 and 2000 feet above aircraft altitude.
Low Density Yellow Dots	Terrain that is 500 feet (250 feet with gear down) below to 1000 feet above aircraft altitude.
Solid Green	(Peaks Only) Highest terrain not within 500 (250 with gear down) feet of aircraft altitude. May appear with dotted yellow terrain when the aircraft altitude is within 500 feet (250 feet with gear down) of terrain.
High Density Green Dots[1]	Terrain that is 500 (250 with gear down) feet below to 1000 below aircraft altitude.
	(Peaks Only) Terrain that is the middle elevation band when there is no red or yellow terrain areas within range on the display.
Low Density Green Dots	Terrain that is 1000 to 2000 feet below aircraft altitude.
	(Peaks Only) Terrain that is the lower elevation band when there is no red or yellow terrain areas within range on the display.
Black	No significant terrain.
Low Density Cyan Dots	(Peaks Only) Terrain elevation equal to 0 feet MSL (requires compatible display).
Low Density Magenta Dots	Unknown terrain.

[1] High density green dots in Peaks mode have a higher density than in standard display mode.

TABLE 6.7-1: DISPLAY COLORS AND PATTERNS

On some Keyed Component Picture Bus (KCPB) terrain displays, an indication of Geodetic Sea Level (GSL) altitude will appear (unless suppressed by display software). This altitude is the reference altitude for the display and the terrain awareness algorithm. In the MK VI and VIII EGPWS, this reference altitude is based on internally calculated Geometric Altitude (see section 6.7.8) and NOT corrected barometric altitude. It represents the aircraft's calculated true height above sea level (MSL) and serves as the reference altitude for color coding of the terrain display (see Table 6.7-1). Because it is primarily comprised of GPS altitude, this reference altitude will often differ from cockpit displayed corrected barometric altitude. This altitude is not to be used for navigation. It is presented to provide the crew with additional situational awareness of true height above sea level, upon which terrain alerting and display is based.

6.7.4.1 Background Display

There are two different background Terrain Awareness display modes: standard and Peaks. For both modes the background display is computed from the aircraft altitude with respect to the terrain data in the digital elevation matrix overlays.

For standard mode, terrain is displayed using colors and shading patterns corresponding to the vertical displacement between the terrain elevation and the current aircraft altitude. Red and yellow dot patterns indicate terrain near or above the current altitude of the aircraft. Solid yellow and red colors indicate caution and warning areas relative to the flight path of the aircraft. High and low density green display patterns indicate terrain that is below the aircraft and within 2000 feet of the aircraft altitude. Terrain more than 2000 feet below the aircraft is not displayed and the terrain display is typically blank during the enroute portion of the flight.

The optional Peaks display adds additional density patterns and level thresholds to the standard mode display levels and patterns. These additional levels are based on absolute terrain elevations relative to the range and distribution of terrain in the display area. The Peaks display is thus a "merged" display applicable to all phases of flight. At altitudes safely above all terrain for the display range chosen, the terrain is displayed independent of aircraft altitude emphasizing the highest and lowest elevations to provide increased situational awareness. This increased awareness can be particularly valuable to the flight crew in the event of an unplanned descent or off-route deviation and for the purpose of previewing terrain prior to descent.

The Peaks display includes a solid green level to indicate the highest non-threatening terrain. The standard lower density green display patterns indicate mid and upper terrain in the display area as well as terrain that is within 2000 feet of the

aircraft. The red and yellow dot patterns are unchanged and continue to indicate terrain that is near or above the current altitude of the aircraft. Solid yellow and red colors are also unchanged and continue to indicate caution and warning areas relative to the flight path of the aircraft. Terrain identified as water (0 feet MSL) may optionally be displayed as cyan dots if the aircraft display hardware supports the color cyan. The Peaks display is prioritized such that higher level colors and densities override lower color and densities for maximum situational awareness of the most significant terrain relative to the altitude and flight path of the aircraft.

With the Peaks display, two elevation numbers indicating the highest and lowest terrain currently being displayed are shown on the display. The elevation numbers indicate terrain in hundreds of feet above sea level (MSL). The terrain elevation numbers are displayed with the highest terrain number on top, and the lowest terrain number beneath it. The highest terrain number is shown in the same color as the highest terrain color pattern on the display, and the lowest terrain number is shown in the color of the lowest terrain color pattern shown on the display. A single elevation number is displayed when the screen is all black or blue as a result of flying over water or relatively flat terrain where there is no appreciable difference in terrain elevations. The elevation numbers on the display are an additional indication that the terrain display is selected.

The Peaks display option is enabled via program pin during aircraft installation of EGPWS. Customers may choose the standard terrain display or the Peaks display. Configurable display options, including the water display option, are defined within the EGPWS computer.

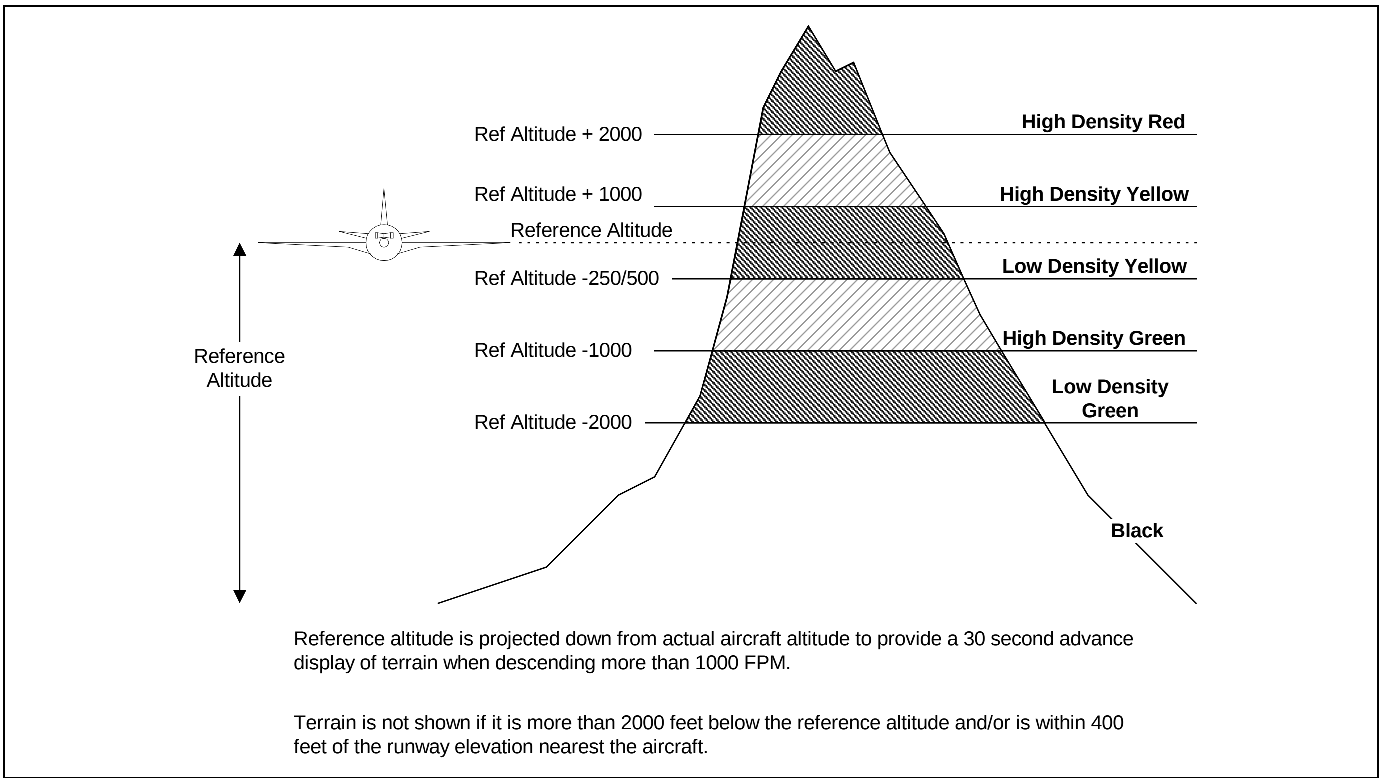
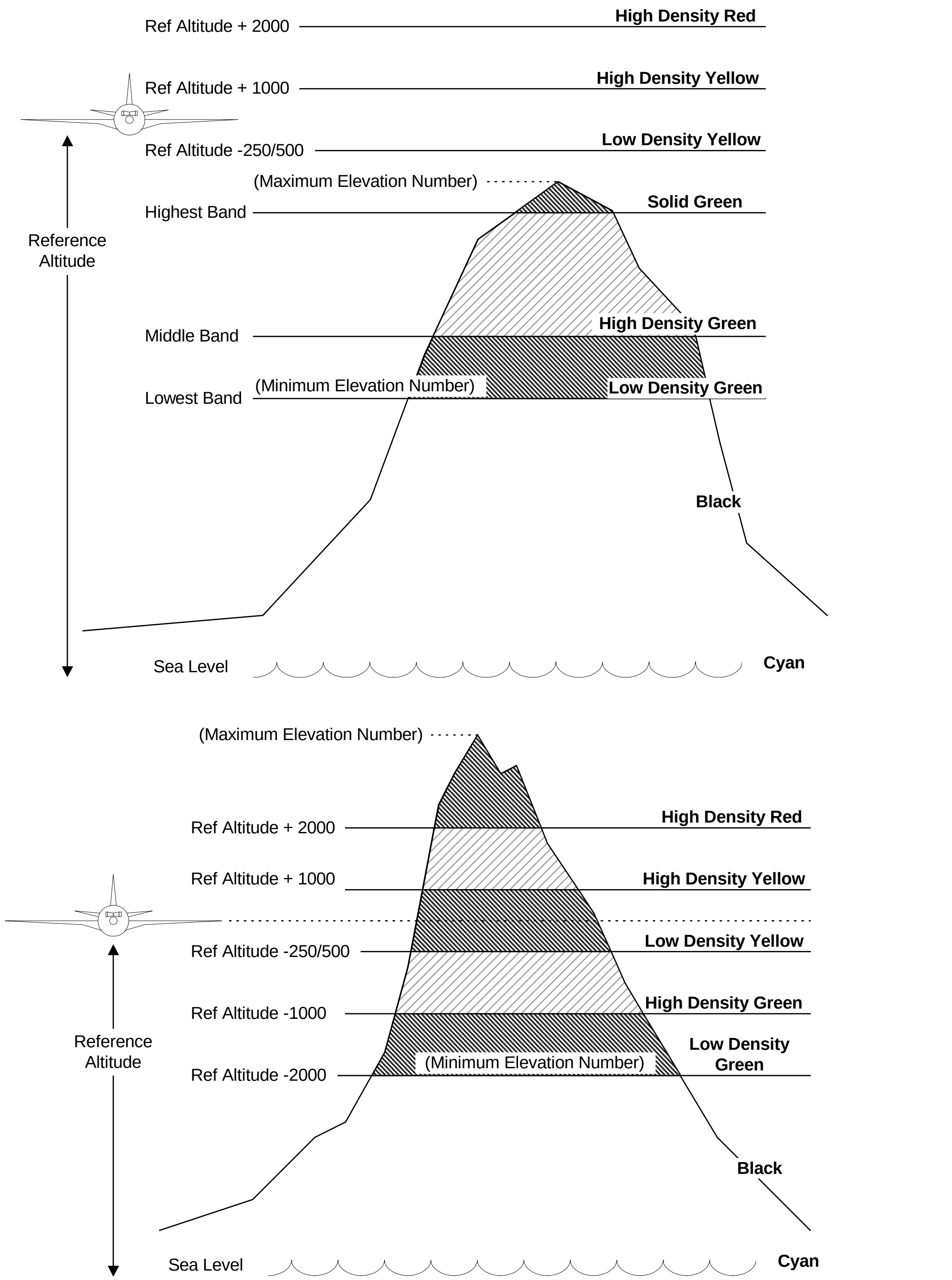


TABLE 6.7-4: STANDARD TERRAIN BACKGROUND DISPLAY



Reference atitude is projected down from actual aircraft altitude to provide a 30 second advance display of terrain when descending more than 1000 FPM.

Terrain is not shown if it is below the lowest band and/or is within 400 feet of the runway elevation nearest the aircraft. Sea level water is displayed if supported by the display.

TABLE 6.7-5: PEAKS TERRAIN BACKGROUND DISPLAY AT HIGH AND LOW RELATIVE ALTITUDES

<u>SELF-TEST TERRAIN DISPLAY</u>

During self-test, if all required inputs are valid then a display test pattern will be painted for approximately 12 seconds. The test pattern, as illustrated in the Figure below, consists of 9 blocks, each filled with a different fill pattern and color. These 9 'styles' reflect those that are normally used in a terrain picture on the display being used.

Magenta	High Density Red	Black or Low Density Cyan*
Solid Red	High Density Yellow	Solid Yellow
High Density Green*	Low Density Yellow	Low Density or Solid Green*

<u>Figure 6.7-6: Self-Test Picture</u>

NOTE: Styles indicated with a * vary depending on the status of the Peaks option

6.7.4.2 Terrain or Obstacle Caution Alert

When the conditions have been met to generate a terrain or obstacle caution alert, a specific audio alert and light output is triggered and the background image is enhanced to highlight the threatening terrain.

At the start of a terrain caution alert, the Terrain Awareness function triggers the voice aural *"Caution Terrain, Caution Terrain"* (or equivalent). The phrase is repeated after seven seconds if still within the terrain caution envelope. The Terrain Awareness function responds to an obstacle caution alert by triggering the obstacle caution voice aural *"Caution Obstacle, Caution Obstacle"*. The phrase is repeated after seven seconds if still within the terrain caution envelope.

During a terrain caution alert or obstacle caution alert the configured lights and 429 output bits are activated.

During a terrain caution alert, areas where terrain violates the terrain caution envelope along the aircraft track, and within ±90° of the aircraft track, are painted with the caution color <u>yellow</u>.

During an obstacle caution alert areas where an obstacle violates the terrain caution envelope along the aircraft track, and within ±90° of the aircraft track, are painted with the caution color <u>yellow</u>.

6.7.4.3 Terrain or Obstacle Warning Alert

When the conditions have been met to generate a terrain or obstacle warning alert, a specific audio alert and light output is triggered and the background image is enhanced to highlight the terrain or obstacle <u>caution and warning</u> threats.

At the start of a terrain warning alert, the Terrain Awareness function triggers the voice aural *"Terrain Terrain, Pull Up"*. The phrase *"Pull Up"* is then repeated continuously while within the terrain warning envelope. The Terrain Awareness function responds to a obstacle warning alert by triggering the obstacle warning voice aural *"Obstacle Obstacle, Pull Up"*. The phrase is repeated continuously while within the terrain warning envelope.

During a terrain or obstacle warning alert the configured lights and 429 output bits are activated.

During a terrain warning alert, areas where terrain violates the terrain warning envelope along the aircraft track, and within ±90° of the aircraft track, are painted with the warning color <u>red</u>.

During an obstacle warning alert, areas where an obstacle violate the terrain warning envelope along the aircraft track, and within ±90° of the aircraft track, are painted with the warning color <u>red</u>.

6.7.4.4 Terrain Test Display

During manually initiated self-test (see 6.10.6), the terrain alert aurals are included in the GPWS audio test outputs. Additionally, a test display is output to the EGPWS display devices. This terrain test display exercises the complete set of EGPWS colors and dot patterns.

6.7.4.5 Mode Annunciation

For some installations a 6 character mode annunciation display window is available to the EGPWS. For these installations the system transmits encoded ASCII characters on its ARINC 429 output for use by the display.

Under normal conditions GPS position is used for the terrain display. When GPS is not available the system can default to IRS position, or possibly to FMS position. This will be annunciated in the message window as follows:

When GPS position is being used, the message window displays **GPWS** or **TERR** in cyan letters.

When FMS position is being used, the message window displays **GPWS-F** or **TERR-F** (in cyan letters).

When IRS position is being used, the message window displays **GPWS-I** or **TERR-I** (in cyan letters).

For some installations, terrain awareness manual inhibit will cause **INHIB** (in cyan letters) to be displayed.

6.7.5 Terrain Database

As shown in Figure 6.7-1, local terrain processing extracts and formats local topographic terrain data from the EGPWS terrain database for use by the terrain threat detection and display processing functions. This terrain database divides the earth's surface into grid sets referenced horizontally on the geographic (latitude/longitude) coordinate system of the WGS-84. Elements of the grid sets record the highest terrain altitude (above MSL) in that element's respective area. Grid sets vary in resolution depending on geographic location. Because the overwhelming majority of "Controlled Flight into Terrain (CFIT)" accidents occur near an airport and the fact that aircraft operate in closer proximity to terrain near an airport, higher resolution grids are used around airports. Lower resolution grids are used outside of airport areas where aircraft altitude enroute makes CFIT accidents unlikely and for which detailed terrain features are less important to the flight crew.

Digital Elevation Models (DEMs) are available for most of the airports around the world today. In cases where the data are not currently available, DEMs are generated in-house from available topographic maps, sectional charts, and airline approach plates. The process of acquiring, generating, assembling, and updating the database is governed by strict configuration controls to insure the highest level of data integrity. DEMs from external sources are inputs to this process and are checked and formatted for generation of the EGPWS Terrain Database.

The EGPWS terrain database is organized in a flexible and expandable manner. Using digital compression techniques, the complete database is stored in non-volatile memory within the LRU. Updates and additions are easily accomplished by inserting a single PCMCIA card in a card slot on a smart cable connected to the LRU. Status LEDs on the smart cable allow the operator to monitor the database load progress and completion.

6.7.6 Obstacle Database

The obstacle database is a separate file from the terrain database. The obstacle database is included with the terrain database in the terrain database PCMCIA card. Both files are loaded into the EGPWS with the obstacle database being accessed by the EGPWC application only if enabled via configuration module option. The obstacle data is processed by the display processing function in the same fashion as terrain is presented on the display as terrain (coloring scheme), and causes visual indications of warning and caution alerts like terrain.

6.7.7 Internal Magnetic Variation Database

Using the International Geomagnetic Reference Field (IGRF), which is a series of mathematical models of the earth's main magnetic field and its secular variation, a global grid of magnetic variation values was generated using one degree intervals in latitude and longitude. The resulting table is embedded into the EGPWC. Using two-dimensional interpolation, magnetic variation is calculated for any position between the grid points. The internal magnetic variation database is included with the terrain database in the terrain database PCMCIA card.

6.7.7.1 Use of Internal Magnetic Variation Database

For the EGPWS terrain display output true heading is required. Magnetic track or magnetic heading is required for envelope modulation and mode 5. On some aircraft types one of these signals is not available. In that case the EGPWS sums magnetic variation with an available signal to compute the required signal. So, magnetic variation is needed when:

There is no direct source of true heading, but there is a source of magnetic heading.
There is no direct source of magnetic track, but there is a source of true track.

6.7.8 Geometric Altitude

Geometric Altitude is a computed aircraft altitude designed to help ensure optimal operation of the EGPWS Terrain Awareness and Display functions through all phases of flight and atmospheric conditions. Geometric Altitude uses an improved pressure altitude calculation, GPS altitude, radio altitude, and terrain and runway elevation data to reduce or eliminate errors potentially induced in corrected barometric altitude by temperature extremes, non-standard altitude conditions, and altimeter miss-sets. Geometric Altitude also allows continuous EGPWS operations in QFE environments without custom inputs or special procedures by the flight crew when operating in a QFE environment.

6.7.8.1 Required Inputs for Geometric Altitude

The Geometric Altitude computation requires GPS altitude with Vertical Figure of Merit (VFOM) and RAIM failure indication along with standard (uncorrected) altitude and radio altitude. Ground speed, roll angle, and position (latitude and longitude) are used indirectly and are also required. Additionally, corrected barometric altitude, Static Air Temperature (SAT), GPS operational mode and the number of satellites tracked are used if available.

The required GPS signals can be provided directly from an external ARINC 743 / 743A receiver or from the optional internal EGPWS Xpress GPS Receiver card. Standard altitude, corrected barometric altitude, and SAT are provided directly from the ADC. If SAT is not available, Geometric Altitude is computed using standard altitude with a corresponding reduction in accuracy.

6.7.8.2 Altitude Calculation

The Geometric Altitude consists of three main functions: calculation of non-standard altitude, calculation of the component altitudes and VFOMs, and the final altitude signal blending. Additional logic exists to handle reversionary modes and signal reasonable checking for each component altitude. An overview of the Geometric Altitude function is shown in Figure 6.7-7.

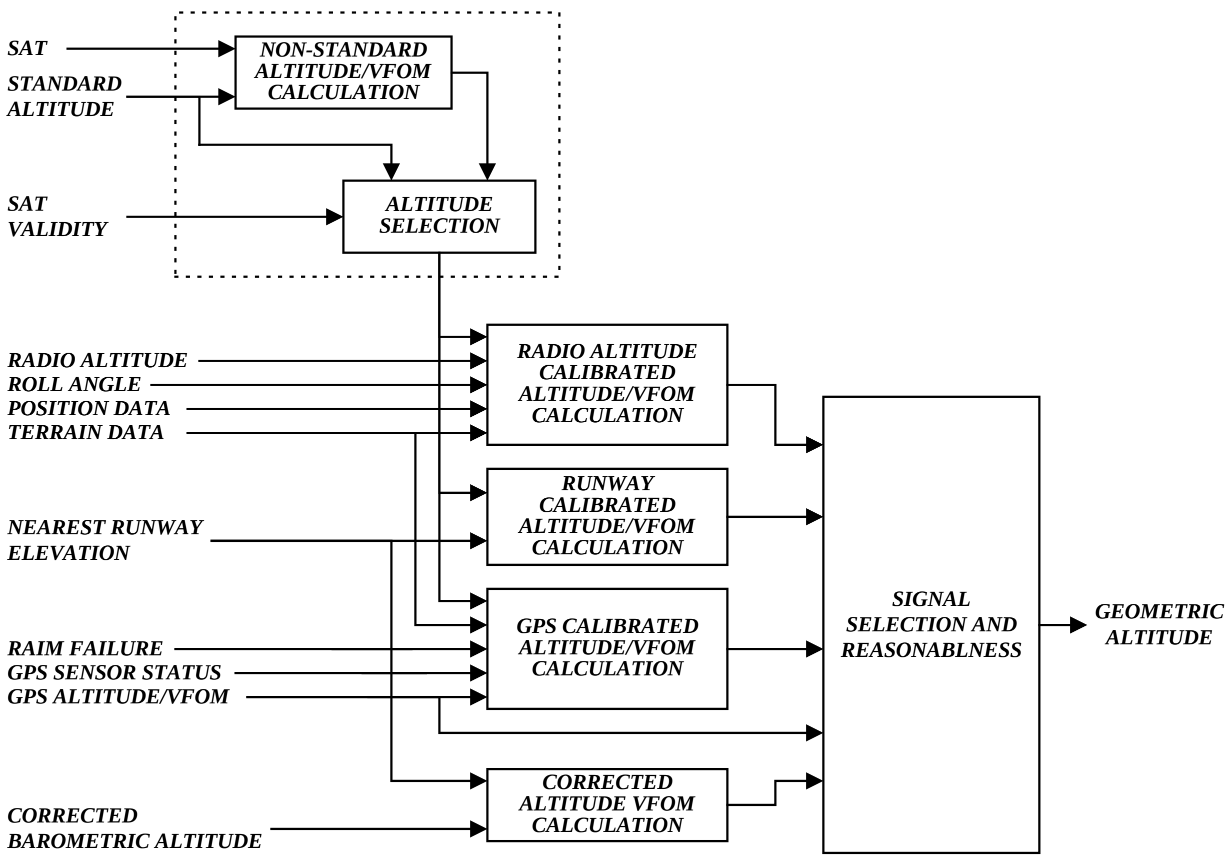


TABLE 6.7-7: GEOMETRIC ALTITUDE BLOCK DIAGRAM

6.7.8.2.1 Non-Standard Altitude

To support the Geometric Altitude function the EGPWS computes a non-standard altitude using the hydrostatic equation relating changes in height to changes in pressure and temperature. Non-standard altitude uses static pressure derived from standard altitude (uncorrected barometric altitude), along with SAT, to continuously accumulate changes in Geometric Altitude. Since the non-standard altitude algorithm incorporates actual atmospheric temperature it does not suffer from errors due to non-standard temperatures.

Non-standard altitude is highly accurate for measuring relative vertical changes over short periods of time and distance, such as during take-off and approach. Non-standard altitude does not provide an absolute altitude and is prone to significant errors over extended periods of time and distance due to the effects of pressure gradients and long term integration errors. Due to these limitations, non-standard altitude is not used directly, but is calibrated using additional signals and data to produce a set of component altitudes for use in the final altitude solution.

6.7.8.2.2 Computed Component Altitudes

The EGPWS generates three component altitudes that are combined, along with corrected altitude if available, to produce Geometric Altitude. These component altitudes are runway calibrated altitude, GPS calibrated altitude, and radio altitude calibrated altitude.

Runway Calibrated Altitude, is a one-time calibration of non-standard altitude during take-off roll. A correction factor for non-standard is computed using the runway elevation from the EGPWS runway database while the aircraft is on the ground. Runway calibrated altitude is used during the take-off and climb-out portions of flight. VFOM of runway calibrated altitude is estimated based on changes in altitude since calibration, time since calibration, and distance from the runway.

GPS Calibrated Altitude is produce by combining GPS altitude and non-standard altitude through a complementary filter. The complimentary filter is dynamically optimized to reduce errors in GPS altitude caused by selective availability while minimizing pressure gradient and drift errors of non-standard altitude. GPS calibrated altitude is accurate through all phases of flight and is the primary altitude source during the cruise portion of flight. GPS calibrated altitude VFOM is estimated using GPS VFOM and estimated non-standard altitude drift errors.

Radio Altitude Calibrated Altitude is a calibration of non-standard altitude during approach using an altitude derived from radio altitude (height above terrain) and the terrain elevation data stored in the EGPWS terrain database. This calibration is performed during the approach phase of flight when the aircraft is within a minimum distance and elevation of any runway. Once a correction factor is determined, it is applied to non-standard altitude until the aircraft lands. VFOM of radio altitude calibrated altitude is based on the accuracy of the calibration as estimated from the resolution of the terrain data and flatness of the terrain. The altitude is re-calibrated if a correction with a higher estimated accuracy is computed.

An estimated VFOM for corrected barometric altitude is computed in order to determine its weight in the final altitude. VFOM of corrected barometric altitude is based on aircraft altitude above and distance from the nearest runway, with the accuracy assumed to be the highest close to runway.

6.7.8.2.3 Blending and Reasonableness Checking

The final Geometric Altitude is computed by combining the three computed component altitudes with optional corrected barometric altitude. The weighting of each altitude in the final solution is based on the corresponding estimated VFOM. The blending algorithm gives the most weight to altitudes with a higher estimated accuracy, reducing the effect of less accurate altitudes on the final computed altitude. Each component altitude is also checked for reasonableness using a window monitor computed from GPS altitude and GPS VFOM. Altitudes that are invalid, not available, or fall outside the reasonableness window are not included in the final blended altitude.

6.7.8.3 Input Failures and Reversionary Operation

The Geometric Altitude algorithm is designed to allow continued operation when one or more of the altitude components are unavailable. Component altitudes that are unavailable due to a failed input signal or flagged as unreasonable are not used, with the final blended altitude comprised of the remaining, valid signals. If all component altitudes are invalid or unreasonable, then GPS Altitude is used directly for the Terrain Awareness functions. If GPS altitude is invalid then the Terrain Awareness functions operate using corrected altitude when available, otherwise, a Terrain Awareness INOP results.

For installations without SAT or if the SAT input fails, standard altitude is use in place of computed non-standard altitude. Under such conditions, all computed component altitudes normally requiring non-standard altitude use standard altitude with

a corresponding decrease in accuracy. When using standard altitude in place of non-standard altitude, affected estimated VFOMs are adjusted resulting in the affected signals being weighted less heavily in the final blended altitude.

6.7.9 WGS-84 Correction

Some GPS receivers provide GPS altitude referenced to WGS 84 instead of Mean Sea Level (MSL). When the GPS reference configuration item indicates WGS 84 a correction algorithm is applied to correct the GPS altitude from WGS 84 referenced to MSL referenced. If an internal GPS is configured (per configuration module) then the GPS altitude reference configuration item must be set to MSL.

6.7.10 Horizontal Position Source Selection

The MKVI/MKVIII EGPWS supports only a single GPS position source. Switching between sources is not required.

6.8 Envelope Modulation

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Cfg.
29-NOV-99 Peter Bateman	Initial release and entry into PVCS	-001	-001
23-MAY-00 Susie Wright	SCR 4796: Update Envelope Modulation to use Geometric Altitude when available. General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
27-FEB-01 – M. Calhoun	Document only change – Highlighted the fact that if the system is not configured to bring in Localizer, then some Envelope Modulation cases will not be available.	-	-
02-JUL-01 – Susie Wright	Added review comments.	-008	-008

During the past 20 years, experience with Ground Proximity Warning Systems has shown that some approaches to certain airports can be incompatible with the normal alert/warning envelopes and signal filtering.

Honeywell has developed a number of enhancements to the envelopes and filters during this time in an attempt to accommodate these few airports, without compromising the overall GPWS effectiveness for all the other “normal” airport approaches. However, there remain a limited number of cases where problems persist despite these efforts.

All of the noticeable problems have been due to nuisance alerts/warnings for approaches and departures at particular airports. The majority of nuisance alerts/warnings involve Mode 2 closure rate due to terrain under the approach path or rising terrain just before the runway threshold. Others involve Mode 4 terrain clearance alerts during initial approach. A few Mode 1 alerts/warnings are the result of steeper than normal approaches over terrain which slopes down to the runway at some airports.

A different type of problem is inadequate protection during ILS approaches because Mode 5 is limited to less than 1000 feet radio altitude. There are airports located at a significantly higher altitude than the surrounding terrain. In some instances this difference is over 1000 feet, thus requiring the aircraft to be below the runway elevation before a Mode 5 alert is possible during most of the approach.

The Envelope Modulation feature provides improved alert/warning protection at some key locations throughout the world, while improving nuisance margins at others. This is made possible with the use of navigational signals from GPS or FMS navigation equipment. All navigational position data is cross checked to ground based navigational aids, altimeter and heading information, and stored terrain characteristics prior to being accepted for Envelope Modulation purposes. This guards against possible navigational position errors.

After recognizing the approach to or departure from one of these airports, it is also important to verify the aircraft is at a reasonable altitude before desensitizing any warning criteria. If the aircraft is already low, further warning reduction is not desirable. Geometric Altitude data is used for this purpose.

The Geometric Altitude is verified in one of two ways:

1. For ILS approaches, the glideslope deviation is used to establish that adequate terrain clearance exists (i.e. a “normal” approach). Consequently, errors in altitude data will not enable Envelope Modulation during an unsafe condition.
2. When ILS information is not available, stored terrain elevation data is matched against computed elevation data (i.e. Geometric Altitude - radio altitude) to verify altitude. This is done for a “snapshot” location immediately prior to the Envelope Modulation area.

If Geometric Altitude is not of high integrity, corrected barometric altitude is used.

The following additional input data is used to cross check the navigational and altitude information:

Localizer deviation

Magnetic track/heading

Selected runway heading or selected course

Radio altitude

Latitude and longitude are continuously monitored for the airport locations. Additional data processing is not required until the aircraft approaches one of the Envelope Modulation areas. Once a latitude/longitude-defined area is penetrated, the other data inputs are checked for “normal” conditions before any alert/warning envelopes are modulated.

There are currently four types of Envelope Modulation required for the approaches causing problems for GPWS:

1. Bias the Mode 1 alert/warning boundaries for “Sinkrate” and “Pull Up” to the right to allow greater altitude rates before an alert or warning is generated.

2. Lower the maximum upper limit for Mode 2A and Mode 2B. This limits the maximum radio altitude, or the minimum terrain clearance required to generate an alert or warning.

3. Lower the maximum upper limit for Mode 4 to allow less minimum terrain clearance before an alert is generated.

4. Expand the maximum Mode 5 radio altitude level where an alert can begin. This will allow “Glideslope” alerts for higher radio altitudes. The gear down requirement to enable this mode is also overridden during warning expansion, to allow gear up alerts. The maximum radio altitude for Mode 6 “Minimums” alert is expanded at the same time to the same Mode 5 maximum, as well as removal of its gear down requirement.

The actual data for each of the established areas is in tables stored in the EGPWC non-volatile memory. This data can be for either a “snapshot” area or an Envelope Modulation area. In fact, these areas can actually overlap since the Envelope Modulation is not performed until the “snapshot” conditions have been verified. Every “snapshot” area has an associated Envelope Modulation area, but not every Envelope Modulation area has an associated snapshot area. This is because some locations use glideslope instead of the snapshot feature as a crosscheck on Geometric Altitude data. All of the data extracted for each location is used to form a unique key, which establishes the aircraft position, orientation and altitude.

Stored data for latitude, longitude, terrain elevation, expected elevation tolerance, minimum expected radio altitude, heading (track) and maximum allowable time to reach the Envelope Modulation area are compared to real time computed values for these parameters in order to set snapshot latch. This latch is intentionally stored in volatile RAM memory and cleared during power loss recovery. The associated signal validities are used to establish signal integrity prior to setting the snapshot latch. The maximum time term is used to clear the snapshot latch once this time has expired unless the Envelope Modulation conditions are satisfied first.

Logic is required to satisfy one or more of the Envelope Modulation keys. In each case, if the key is required, the associated conditions are monitored.

Please note that other than Localizer, all Envelope Modulation required inputs are also required for basic GPWS so they will be available. However, Localizer, which is not required for basic GPWS functionality, may not necessarily be available. If the Navigation Input category does not select an ID containing Localizer, then the Envelope Modulation cases requiring Localizer will not be available.

The following is a summary of the Envelope Modulation and snapshot keys:

TABLE 6.8-1: ENVELOPE MODULATION KEYS

Selected Key	Description
Envelope Modulation Area	Requires valid latitude and longitude to be with defined area
G/S Selected	Requires valid glideslope within +/- 2 dots
Loc Selected	Requires valid localizer within +/- 2 dots
Hdg Selected	Requires valid heading within +/- 30 deg of selected value
Crs Selected	Requires valid runway course within +/- 10 deg of selected value If the aircraft installation does not provide runway course (or selected heading) then this key is not required.
Min Altitude Selected	Requires valid Geometric Altitude to be greater than selected value
Snapshot Selected	Requires snapshot detected

TABLE 6.8-2: SNAPSHOT KEYS

Selected Key	Description
Snapshot Area	Requires valid latitude and longitude to be with defined area
Hdg Selected	Requires valid heading within +/- 30 deg of selected value
Minimum Radio Altitude	Requires valid radio altitude to be greater than selected value
Terrain Elevation	Requires terrain elevation to be within a specific tolerance of the selected value
Maximum Time	Maximum time permitted to satisfy all envelope modulation keys after leaving the snapshot

All of the keys, either by virtue of not being selected, or by being selected and satisfied, are required to enable Envelope Modulation. Envelope Modulation parameters are either within the selected values if the keys fit, or defaulted to normal values if the keys don't fit. These parameters are used as inputs to the alert/warning modes and thereby provide the mechanism for Envelope Modulation.

6.9 System Outputs

Revision History

Date - Modified By	Description of the Updates	Effectivity App.	Cfg.
29-NOV-99 Peter Bateman	Initial release and entry into PVCS	-001	-001
24-MAY-00 Susie Wright	SCR 4738: Add lamp format 2. General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
01-DEC-00 – Susie Wright	General document cleanup.	-006	-006
27-FEB-01 – M. Calhoun	SCR 5803: Added 6.9.3.7 for Steep Approach Lamp.	-008	-008
11-JUN-01 – P. Bateman	SCR 5794: Updated section 6.9.3 for addition of Flashing lamps.	-008	-008
02-JUL-01 – S. Wright	Added review comments	-008	-008

This section describes the various outputs available with the EGPWS. Refer to the table in section 1.2.5.1 for a summary of I/O capability.

6.9.1 Serial Output

The EGPWC provides two ARINC 429 output channels. Refer to the Installation Design Guide for a list of each of the specific ARINC 429 output labels provided. These outputs consist of internal parameters that can be used for test purposes, and discrete outputs that can be used both for test, driving EFIS displays, and recording. During EGPWS self test the SSM of each output label is set to the functional test status code. The output types can be summarized as follows.

1) Internal data: Some internal data is output for test purposes only such as radio altitude used, computed true airspeed, etc.

2) Alert status: Each type of voice and lamp activity is mapped to a specific label/bit. This can be used to provide inputs to EFIS (MKVIII EGPWS) and flight recorders.

3) Internal Mode status: Various internal EGPWC mode logic is transmitted for test purposes.

4) Fault diagnostic words are provided.

Also two channels of ARINC 453 data are provided to drive terrain displays for installations that use the Terrain Awareness display function.

6.9.2 Audio Output

Mode computation outputs generally result in an audio voice message unless inputs are invalid or one of the audio suppression discretes is active. The actual output message, or intended message during audio suppression, is sent to the alert lamp logic for proper output activation.

The audio outputs consist of an 8-ohm amplifier to drive a flight deck speaker and a transformer isolated 600-ohm output to drive audio interphone systems. The output volume is selectable as a configuration item (refer to the Installtion Design Guide) which reduces the volume in steps of 6dB from the maximum (default) value. In addition a discrete can be used to reduce the volume by a fixed 6dB for altitude callouts.

Two sets of voice messages are defined. Each set is selected by audio menu configuration. Refer to the Installtion Design Guide for specific audio menu set definitions.

Table 6.9-1 is a list of the messages that can be selected for various alert conditions. The lamp column shows which lamp output that an alert activates.

The audio inhibit discrete logic controls the audio outputs as follows. If selected then all voices are inhibited . An audio on output discrete is set whenever an EGPWS audio message is active. This output is used to inhibit other audio systems.

RELATIVE PRIORITY	WARNING CONDITION	POSSIBLE MESSAGES	LAMP FORMAT 1	LAMP FORMAT 2
HIGHEST	Mode 7 W/S Warning	W/S W/S W/S	W/S WARN	W/S WARN
	Mode 1 Pull Up	Pull Up	GP WARN	GP WARN
	Mode 2 Pull Up Preface	Terrain Terrain	GP WARN	GP CAUTION
	Mode 2 Pull Up	Pull Up	GP WARN	GP WARN
	Terrain Awareness Preface	Terrain Terrain Terrain Ahead	GP WARN GP WARN	GP CAUTION GP CAUTION
	Terrain Awareness Warning	Pull Up	GP WARN	GP WARN
	Obstacle Awareness Preface	Obstacle Obstacle Obstacle Ahead	GP WARN GP WARN	GP CAUTION GP CAUTION
	Obstacle Awareness Warning	Pull Up	GP WARN	GP WARN
	Mode 2 Terrain	Terrain	GP WARN	GP CAUTION
	Mode 6 Minimums	Per selected menu	No Lamp	No Lamp
	Terrain Awareness Caution	Caution Terrain-Caution Terrain Terrain Ahead-Terrain Ahead	GP WARN GP WARN	GP CAUTION GP CAUTION
	Obstacle Awareness Caution	Caution Obstacle-Caution Obstacle Obstacle Ahead-Obstacle Ahead	GP WARN GP WARN	GP CAUTION GP CAUTION
	Mode 4 Too Low Terrain	Too Low Terrain	GP WARN	GP CAUTION
	TCF Too Low Terrain	Too Low Terrain	GP WARN	GP CAUTION
	Mode 6 Altitude Callouts	Per selected menu	No Lamp	No Lamp
	Mode 6 Smart Callout	Five Hundred	No Lamp	No Lamp
	Mode 4 Too Low Gear	Too Low Gear (Note 1)	GP WARN	GP CAUTION
	Mode 4 Too Low Flaps	Too Low Flaps	GP WARN	GP CAUTION
	Mode 1 Sinkrate	Sinkrate-Sinkrate	GP WARN	GP CAUTION
	Mode 3 Don’t Sink	Don’t Sink-Don’t Sink	GP WARN	GP CAUTION
	Mode 5 Glideslope	Glideslope	G/S CAUTION	G/S CAUTION
	Mode 6 Bank Angle	Bank Angle	No Lamp	No Lamp
LOWEST	Mode 7 W/S Caution	No Audio, or Caution Windshear	W/S CAUTION	W/S CAUTION

Note 1: For fixed gear aircraft this warning condition provides a “Too Low Flaps” message.

TABLE 6.9-1: WARNING/CAUTION MESSAGES

The EGPWS also has vocabulary for annunciating EGPWS status, current faults, fault history, and self-test operation.

6.9.3 Discrete Outputs

Outputs from the various alert computations are first processed to determine which lamp outputs to produce.

All of the lamp outputs are driven by solid state switches to ground. These outputs can also be used as discrete drivers for other devices.

All caution/warning lamp outputs are normally a steady state switch to ground. The lamps can be individually programmed to flash as a function of aircraft type only. The flashing outputa operats at a nominal 70 cycles per minute at a 50% duty cycle.

6.9.3.1 Ground Proximity Caution Discrete (Lamp) Outputs

Two lamp formats are defined as a function of the selected I/O discrete type. For lamp format type 1, only the Mode 5 “Glideslope” message will activate the caution lamp output (amber). All other messages, including Terrain Awareness, will activate the warning lamp output (red). Note that Mode 6 does not activate any lamp outputs, only voices.

With lamp format 2, only the messages containing the phrase “Pull Up” will activate the warning lamp output (red). All other messages will activate the caution lamp output (amber).

The glideslope cancel discrete controls the output of the Mode 5 “Glideslope” message. If the glideslope cancel discrete is activated then the caution lamp (amber) and the voice ennunciation will be inhibited for the Mode 5 “Glideslope” message.

6.9.3.2 Windshear Discrete (Lamp) Outputs

The Mode 7 Windshear detection warning and caution functions activate separate lamp outputs. Priority logic, described in section 6.5, prevents windshear caution during a windshear warning condition and provides an inhibit which turns off the EGPWS alert and warning lamps.

6.9.3.3 Audio On Discrete

The Audio On output is activated whenever the EGPWS is talking. It will stay on until the voice is completed. This output can be used to inhibit other audio systems during GPWS alerts and callouts. In addition it can be used to drive the audio key line input provided on some aircraft audio systems.

6.9.3.4 Terrain / Obstacle Awareness Alert Discretes

Terrain Awareness provisions for 2 discrete alert outputs, one for terrain and obstacle cautions and one for terrain and obstacle warnings. For the MKVI and MKVIII these outputs contribute to the GPWS warn lamp.

The TA & TCF inhibit discrete logic always disables the setting of this discrete due to Terrain Awareness.

6.9.3.4.1 Terrain / Obstacle Caution Discrete

Terrain/obstacle caution will activate a discrete output. The alert will activate the GPWS Warn Lamp if Lamp Format 1 is selected or the GPWS Caution Lamp if Lamp Format 2 is selected. In addition, ARINC output discrete bits for each of Terrain and Obstacle Cautions are included.

6.9.3.4.2 Terrain / Obstacle Warning Discrete

Terrain/Obstacle Warning will activate a discrete output. The alert will activate the GPWS Warn Lamp. In addition, ARINC output discrete bits for each of Terrain and Obstacle Warnings are included.

6.9.3.5 Monitor Discretes (GPWS INOP, Terrain INOP & Terrain Not Available)

The EGPWC produces two discrete monitor outputs. These discretes reflect the following functions, GPWS INOP, and Terrain INOP or Terrain Not Available. Both of these discretes activate with loss of EGPWC power. The status of the three inputs to these discretes is also contained on an ARINC 429 output word.

6.9.3.6 Terrain Display Switching Discretes

The EGPWC produces two discrete outputs for controlling the terrain display. They can be used either to control picture bus switching relay(s) or connected directly to the symbol generators. Refer to section 6.9.4.2.

6.9.3.7 Steep Approach Discrete

For those Discrete I/O IDs that include a momentary Steep Approach input discrete, an associated Steep Approach Activated lamp output is also supplied. This discrete output is turned on whenever Steep Approach is activated, either via pilot selection, or if Steep Approach is automatically activated via Envelope Modulation.

6.9.4 Display Output and Control

The Terrain Display (EGPWD) component of the EGPWS is divided into the functional blocks shown in Figure 6.7-1. Terrain display data and range scale settings for up to two weather displays are delivered to the Display Signal Processor (DSP) from the Terrain Threat Detection and Display Processing and Display Control Logic blocks. The DSP performs the real-time rendering of the EGPWD synthetic radar sweep and provides outputs for both ARINC-708 display buses. The Display Control Logic also provides discrete signals and an ARINC-429 status bus to the external display system to control final selection and annunciation of the EGPWD or Weather image. As described in each related sub-section, these outputs are wired as required for the specific aircraft installation.

6.9.4.1 Display Signal Processor

The Display Signal Processor (DSP) receives aircraft-local terrain data from the Terrain Threat Detection and Display Processing block. These data are contained in a set of display matrix overlays that hold display attributes rather than altitude for each matrix element. These attributes have been computed by the Terrain Threat Detection and Display Processing block for the background and terrain threat areas and kept small to reduce memory requirements and transfer time to the DSP.

The attributes within the display matrix overlays identify caution and warning threat areas and background terrain. Threats are highlighted by the DSP in unique, solid colors while background terrain is displayed using fractal-like dot patterns. These dot patterns vary in density to convey approximate terrain altitude with respect to the aircraft. Areas with no terrain data available are also displayed with a fractal-like dot pattern but with a unique color. (Refer to section 6.7.4).

The DSP performs a rho-theta conversion of the display matrix overlays using current aircraft position and aircraft heading and synthesizes a radar-like sweep ahead of the aircraft. This sweep can feed two display outputs with independent range scale settings.

6.9.4.1.1 Output Display Buses

The EGPWS provides two output buses that conform electrically to ARINC-453 and implement the ARINC-708 data formats used by weather radar. The EGPWS output formats are configurable for the type of display and provide the capability to drive two independent radar displays using either of two ARINC-708 display addressing standards:

- Time Shared: single multiplexed data stream for two independent displays.
- Space Addressed: two individual output data streams for two independent displays.

The "time shared" configuration is normally used by Multi-function Display (MFD) systems such as an EFIS providing a single output display bus with data for two independent displays. The "space addressed" configuration provides two separate and independent outputs for driving combinations of displays comprising weather radar indicators and/or MFDs. The second display output bus may be wired as needed for the specific aircraft installation.

6.9.4.1.2 KC Picture Bus (KCPB)

The KC Picture Bus, KCPB, is the specification of a family of proprietary data formats intended for the transport of digital image pixel data, such as terrain data. Digital image pixel data is in the form of rasterized or X/Y format. This format does not require a rho-theta to X/Y conversion that can introduce conversion and overlap errors and allows use of the entire X/Y screen of the display. Text data consist of data generated for range, mode, heading, Peaks altitude, test status, and alerts.

For a detailed description of the KCPB specification see EGPWS Interface Methodology, 060-4303-000. The KCPB specification defines the header structure of the bus as well as what types of representation may be used for the pixel coding.

Minimum KCPB implementations must include raster image data and display support of query or continuous response. A typical KCPB implementation will also include key press data. A full up KCPB implementation will support palette definition and text data.

All KCPB compatible displays support either the query response (on-demand) or the continuous response. The query response interactive protocol is used for displays that support a dedicated KCPB input bus. For all other displays, KCPB compatibility is ensured by having the respective displays continuously output their configuration on ARINC 429.

The EGPWC will query the display for type information to setup the display interface. The KCPB compatible display will either respond to this query, or provide a continuous response. At power up, the EGPWC will monitor the activity of the bus on which the response comes in on and will use it to detect that the display system is powered and connected. Upon detection of bus activity, the EGPWC will send a query via ARINC 453 asking the display to respond with configuration information, and then it will listen for a response (query or continuous) via ARINC 429. For dual display configurations each side queries independent of the other. If, after several attempts to receive the display configuration data, there is no response after a set time, or the response is invalid or unintelligible, then the EGPWC will display a configuration failure on the respective display and will advise the display that it's not functioning properly.

6.9.4.2 Display Selection and Control Outputs

The display control logic block, shown in the previous Figure 6.7-1, provides signals to control the selection of EGPWD or weather display for each display and also to control EGPWD range selections depending on cockpit switch selections, current EGPWD threat conditions. The EGPWD may also be configured to automatically optimize the range scale of the EGPWD display when a terrain alert is detected.

The display control logic makes use of configuration input data and provides several outputs that may be wired as required for specific aircraft installations.

6.9.4.2.1 Wx/EGPWD Select and Pop-Up Discretes

Provision is made to support two means of selecting between weather and EGPWD displays:

1. Discrete Cockpit Selection Switch(s) for each display.
2. Selection made within the display controller(s).

Two ground seeking discrete outputs are provided for control of the selection between weather and EGPWD on each display. These discretes perform different functions depending on the display configuration.

Installations that use a cockpit selection switch for each display may use these outputs to directly control relays that make the switch between weather and EGPWD. The EGPWS will read each connected cockpit selection switch and output the corresponding selection. The EGPWS may also be optionally configured to pop-up the terrain display when an EGPWS alert is detected thereby overriding the crew selections.

Systems with Multi-function Displays (MFD) such as an EFIS will prefer to control Wx/EGPWD selection from the MFD. When the MKVIII EGPWS is configured for this type of display, these discrete outputs serve as pop-up discretes for each display. These systems may then optionally include the EGPWS alert pop-up discrete in their internal selection logic to override the crew selection during a terrain threat.

6.9.4.2.2 EGPWD Status

EGPWD status data is available on an ARINC-429 broadcast output bus. This data includes the current EGPWD status, range scale selections, EGPWD alert pop-up discrete status, and a 6-character status message for use by external multi-function displays such as an EFIS (see section 6.7.4.5).

6.10 Maintenance Functions

Revision history

Date - Modified By	Description of the Updates	Effectivity App.	Effectivity Cfg.
29-NOV-99 Peter Bateman	Initial release and entry into PVCS	-001	-001
06-APR-00 M. Calhoun	SCR 4896: Added the following to the Present status example in section 6.10.12 and to the level 3 self test description in section 6.10.6.3: 'IO Discrete Type' 'Engine Torque Type' 'Windshear Input Type' Also revised item order to match actual sequence in 6.10.12.	-003	-003
24-MAY-00 Susie Wright	SCR 4795: Add Envelope Modulation to EM6/8 General document cleanup.	-003	-003
06-JUN-00 – Susie Wright	Document only change – Deleted proprietary note from footer.	-003	-003
01-DEC-00 – Susie Wright	General document cleanup.	-006	-006
27-FEB-01 – M. Calhoun	SCR 5803: Added Steep Approach lamp to self test.	-008	-008

The EGPWS maintenance philosophy is to provide information that will encourage the line mechanic to correct the real problem (pull the correct LRU) by indicating whether the failure is within the EGPWC or one of the input sources. To that end, the EGPWS is designed to provide extremely clear (not necessarily detailed) fault messages, and give them with minimum effort on the part of the maintenance crew. To accomplish this goal, the EGPWC provides four different means of extracting fault information, provides access from either the cockpit or the EGPWC, and provides several levels of reporting, from the very basic to the very detailed. The three methods of accessing fault information from the EGPWC are aurally, over RS-232, and by download to the PCMCIA port via the smart cable. Aural readout can be performed in the cockpit. Additionally some information is also conveyed over ARINC 429.

6.10.1 Maintenance Philosophy

The EGPWC performs both event-initiated and continuous BIT functions. Event-initiated refers to both power up tests and manually activated self-test sequences. The system status monitors are provided to indicate whenever any fault is detected which effect system functionality. These monitors can be activated by any test that fails as a result of both event initiated or continuous BIT. The cockpit self-test is provided both to test the cockpit interface and to annunciate system configuration and status information.

6.10.2 Windshear Monitor

The windshear monitor is activated by failures that affect the windshear fucntion. Both analog and digital versions of the monitor are provided. The configured discrete output is biased on with loss of system power.

6.10.2.1 Current Configuration

Current configuration of the EGPWC indicates the current hardware, software, databases, configuration module and input discrete detected by the system. Each configuration item has a configuration message associated with it. This message is the message that will be read out during present status on the RS-232 interface or voice output during self-test level 3 to inform the user of the current configuration.

Refer to the Installation Design Guide for specific configuration messages associated with each configuration item.

6.10.2.2 Current Faults

Faults and failures in the system are divided into two main categories, internal faults and external faults. These main two categories are used to distinguish faults for different processing requirements. (For example recording faults into fault history.) Faults are further broken down in to sub-categories; discrete faults, ARINC 429 bus activity faults, analog input wire monitoring faults, ARINC 429 signal faults, analog signal faults and configuration module faults. Refer to the Installation Design Guide for specific system status messages for current faults.

Some fault examples are as follows:

FAULT	EXAMPLE	REASON
ARINC 429 Bus Fault	GPS BUS INACTIVE	No expected input labels received for more than 4 seconds
ARINC 429 Signal Fault	ILS BUS GLIDESLOPE FAULT FW	The SSM of the input data indicates Failure/Warning Note: Only the RS232 present status will report the ‘FW” part of the fault.
ARINC 429 Signal Fault	ILS BUS GLIDESLOPE FAULT UPD	The input label is not meeting the required update rate, or is not present. Note: Only the RS232 present status will report the ‘UPD” part of the fault.
Analog Signal Fault	RADIO ALTIMETER WIRING FAULT	Open wire monitoring has detected no connection.
Discrete Input Faults	FLAP SWITCH FAULT	Indicates Landing Flaps for > 60 seconds with an airspeed > 250 knots for GA Fast or 210 knots for GA Slow, or indicates not landing flaps for more than 2 seconds with “Too Low Flaps” message below 100 feet.
	GEAR SWITCH FAULT	Indicates Landing Gear for > 60 seconds with an airspeed > 250 knots, or indicates not landing gear for more than 2 seconds with “Too Low Gear” message below 100 feet.
	GLIDESLOPE CANCEL INVALID	Discrete selected for > 15 seconds.
	RANGE UNREASONABLE	No valid range provided for > 5 seconds.
	SELF-TEST INVALID	Discrete selected for > 60 seconds.
	MOMENTARY TERRAIN SELECT 1 (or 2) INVALID	Selected for > 15 seconds.

6.10.2.2.1 Internal Faults

Internal faults are those faults that originate within the EGPWC. These faults are indicated via the EGPWS front panel “Computer Fail” LED, self-test and the RS-232 and ARINC 429 interfaces.

6.10.2.2.2 External Faults

External faults are those faults that originate from sources outside the EGPWC. The following faults are categorized as external faults: ARINC 429 bus activity faults, analog input wire monitoring faults, ARINC 429 signal faults, and analog signal faults. These faults are indicated via the EGPWS front panel “External Fault” LED, self-test and the RS-232 interface.

6.10.2.3 System Monitors

The system monitor provides three discrete outputs indicating the status (whether a particular function is valid or not). Detected data failures and internal computer failures will activate these outputs. The analog versions of these outputs are designed to remain on when power is off, or the EGPWC experiences catastrophic failure. Front panel LEDs are also provided as described in section 6.10.4.

6.10.2.3.1 GPWS Monitor

The EGPWS monitor is activated by failures that affect the GPWS functions. Both analog and digital versions of the monitor are provided. The configured discrete output is biased on with loss of system power.

6.10.2.3.2 Windshear Monitor (MKVIII EGPWS)
The Windshear monitor is activated by failures that affect the Windshear function. Both analog and digital versions of the monitor are provided. The configured discrete output is biased on with loss of system power.

6.10.2.3.3 Terrain Awareness Monitor
The Terrain Awareness monitor is encoded on an ARINC 429 label and is supplied by the Terrain Awareness function.

6.10.2.3.4 Terrain Not Available Monitor
The terrain not available monitor is encoded on an ARINC 429 label and is supplied by the Terrain Awareness function.

6.10.2.3.5 Envelope Modulation Inop
If any of the needed input data to the Envelope Modulation functionality is not available, the Envelope Modulation INOP is set.

6.10.2.3.6 Terrain Clearance Inop
Terrain Clearance Floor (TCF) INOP is encoded on an ARINC 429 label when any of the needed inputs for terrain clearance are not available.

6.10.2.3.7 Callout Inop
The callout INOP is encoded on an ARINC 429 label whenever an undefined callout menu is selected or if the needed altitude input is faulted.

6.10.2.3.8 Bank Angle Inop
The bank angle INOP is encoded on an ARINC 429 label if either the roll angle or radio altitude inputs are faulted.

6.10.3 LRU Flight history Recording
Flight history in the EGPWS is divided into the following categories: fault history, INOP history, ground history, warning history, status history and cumulative counters. These categories are provided for the recording of faults, alerts and other statistical information required for maintenance of the EGPWS.

6.10.3.1 Fault History
Fault history is stored in non-volatile memory in the form of fault history records. Fault history records contain information that will allow operators to find specific information about faults that occurred during EGPWS operation. Fault history information can be reviewed through the use of the voice output, RS-232 test interface, or uploaded through the PCMCIA interface for later review.

Fault recording is not enabled until at least 25 seconds have elapsed since power up or when on the ATP bench tester.

For multiple occurrences of the same fault in any, one flight leg, only one fault record will be stored.

When the “In Air” status is false, only internal faults are stored. When the “In Air” status is true, both internal faults and external faults are stored. The system is capable of storing a minimum of 256 fault history records and 64 fault legs in non-volatile memory. The required number of faults (256) implies a capability to store an average of 4 faults per leg.

The self-test switch in the cockpit activates the audio fault history readout. Fault history can also be accessed with a PC via the front panel test connector.

6.10.3.2 Fault Statistics
Two forms of fault statistics are maintained: Cumulative counters and INOP history records. Cumulative counters can be used to gather long term statistical data on certain EGPWS parameters. INOP history records can be used to identify specific instances of certain INOP situations for analysis after the fact, to identify causes of these situations. Cumulative counters are intended for internal use and are only available through the RS-232 and PCMCIA interfaces. INOP history information can be reviewed through the use of the voice output, RS-232 interface, or uploaded through the PCMCIA interface for later review.

6.10.3.2.1 Activity Cumulative Counters

For each of the items listed in the table below a cumulative counter will be maintained in non-volatile memory. These counters are never cleared after the time of manufacture.

Cumulative Fault Counters
Glideslope Cancels
Number of Flights
GPW INOP Time
TA&D INOP Time
TA&D Not Available Time
Terrain Inhibit Time
Flight Time
Operating Time

TABLE 6.10.3.2.1.T10:

6.10.3.2.2 INOP history

Each time any of the INOP events in the table below occurs in Air an INOP history record will be created in non-volatile memory. Each INOP history record will contain a list of the current EGPWS faults for the event. Flight leg information and GMT (if available) will also be included for each record.

INOP Event
GPW INOP
Mode 6 INOP
Bank Angle INOP
TA&D INOP
Envelope Modulation INOP

TABLE 6.10.3.2.2.T10:

6.10.3.3 Mode Alerting Activity

Two forms of mode alerting activity history are maintained; alert cumulative counters and alert history records. Alert cumulative counters can be used to gather long term statistical data on alerts encountered. Alert history records can be used to identify specific instances of certain alerts. Alert cumulative counters are intended for internal use and are not available through the audio interface. Warning history information can be reviewed through the use of the voice output, RS-232 interface, or uploaded through the PCMCIA interface for later review.

6.10.3.3.1 Alert Cumulative Counters

For each of the alerts listed in the table below an alert cumulative counter will be maintained in non-volatile memory. Each time the aircraft lands the associated counter will be incremented if its corresponding event occurred in the flight.

GPWS Alert Cumulative Counters
Mode 1 Sinkrate Caution
Mode 1 Pull Up Warning
Mode 2 Pull Up Warning
Mode 2 Terrain Caution
Mode 3 Don’t Sink Caution
Mode 4 Too Low Terrain (Approach) Caution
Mode 4 Too Low Gear Warning
Mode 4 Too Low Flaps Warning
Mode 4 Too Low Terrain (Takeoff) Caution
Mode 5 Glideslope Alert
Mode 6 Bank Angle Callout
Mode 7 Windshear Caution
Mode 7 Windshear Warning
Terrain Clearance Floor Warning
Terrain Ahead Caution
Terrain Ahead Warning
Envelope Modulation Engaged

TABLE 6.10.3.3.1.T10:

As long as the alert occurred at least once during the flight, its associated counter is incremented only once per flight no matter how many times that event occurred during the flight.

The system is capable of storing a minimum of 100 alert history records. Once the limit on the number of alert history records is reached, records will be over-written starting with the oldest records.

6.10.3.3.2 Alert History Records

Each time any of the events listed in table 6.10.3.3.2.T10 occurs, an alert history record will be created in non-volatile memory. Each alert record contains a history of EGPWS signals from 20 seconds prior to the event to 10 seconds after the event. Refer to section 6.10.14.4 for display of warning history.

EGPWS Alert
Mode 1 Outer Curve Voice
Mode 1 Inner Curve Voice
Mode 2 Terrain Voice
Mode 2 Pull-Up Voice
Mode 3 Voice
Mode 4 Too Low Terrain Voice
Mode 4 Too Low Gear Voice
Mode 4 Too Low Flaps Voice
Mode 4 Too Low Terrain Takeoff Voice
Mode 5 Glideslope Voice
Mode 6 Bank Angle Voice
Mode 7 Windshear Caution
Mode 7 Windshear Warning
Terrain Clearance Floor Voice
Terrain Awareness Caution Voice
Terrain Awareness Pull Up Voice
Obstacle Awareness Caution Voice
Obstacle Awareness Pull Up Voice

TABLE 6.10.3.3.2.T10

6.10.3.3.3 Alert History User Interface

The alert history data is accessible via the front panel test connector using a PC, or annunciated during the Flight history audio readout. When the alert history is requested alert history records are scanned and formatted for enunciation or display.

6.10.3.4 Ground History

Ground history consists of *Ground History Records* stored by the EGPWS on the ground for the purpose of maintenance and troubleshooting. The *Ground History Record* will be recorded based on a specific event INOP, self-test or present status. Ground history information can be reviewed through the use of the RS-232 interface or uploaded through the PCMCIA interface for later review.

6.10.3.5 Status History

Status history is used to identify EGPWS status such as database configuration changes, and in some cases, certain input parameters during critical phases of EGPWS operation (e.g. takeoff, landing, change in configuration change, etc.) Status history information can be reviewed through the use of the RS-232 interface, or uploaded through the PCMCIA interface for later review.

6.10.3.6 Flight History Erase Function

Flight history erase is initiated via ATP or RS-232 functionality. Flight history erase will reset the flight leg counter and clear from non-volatile memory **ONLY** the following flight history records:

Fault History Record
INOP History Record
Ground History Record
EGPWS Alert History Record
EGPWS Envelope Modulation Record
EGPWS Status Record
EGPWS Landing Record
EGPWS Configuration Record

NOTE: Flight history Erase will **not** reset any of the cumulative counters.

6.10.4 Front Panel

The EGPWC front panel consists of EGPWS status LEDs, a test connector, two main connectors, and where applicable a GPS antenna connector. A diagram of the status LED's is shown below:

Color		Label
Yellow	O	EXTERNAL FAULT
Green	O	COMPUTER OK
Red	O	COMPUTER FAIL

The EGPWC front panel status LEDs has three LEDs - a yellow external fault LED, a green Computer OK LED and a red Computer Fail LED. The yellow external fault LED indicates that a fault external to the EGPWC exists - do not remove and replace the EGPWC when this condition exists unless the red Computer Fail LED is also illuminated. All external faults should be fixed prior to removing and replacing the EGPWC. The green Computer OK LED indicates that the EGPWC is operating correctly with no internal faults - do not remove and replace the EGPWC when this condition exists. The red Computer Fail LED indicates that the EGPWC has an internal fault - the EGPWC should be removed, replaced and repaired. See table 6.10.4-1 for recommended maintenance actions for each status LED condition.

External Fault	Computer OK	Computer Fail	Condition	Recommended Maintenance Action
OFF	OFF	OFF	EGPWC Power off	Turn EGPWC power ON.
OFF	OFF	RED	EGPWC internal fault exists	Remove, replace and repair EGPWC
OFF	GREEN	OFF	Normal operation	None
OFF	GREEN	RED	Invalid condition	Remove, replace and repair EGPWC
YELLOW	OFF	OFF	Invalid condition	Remove, replace and repair EGPWC
YELLOW	OFF	RED	Both EGPWC internal and EGPWS external faults exist	Troubleshoot external faults using EGPWC self-test if possible. Remove, replace and repair EGPWC.
YELLOW	GREEN	OFF	EGPWS external fault exists	Troubleshoot external faults using EGPWC self-test.
YELLOW	GREEN	RED	Invalid condition	Remove, replace and repair EGPWC

TABLE 6.10.4-1: RECOMMENDED MAINTENANCE ACTION FOR STATUS LED CONDITIONS

The EGPWC front panel provides file download and upload capabilities via a Smart Cable connected to the test port, as described in section 6.10.5.

The EGPWC front panel test plug provides various communications support capabilities, discretes used for file downloading and power outputs for the Smart Cable. Table 6.10.4-2 describes the function of each pin for both the MKVI and the MKVIII EGPWCs. Table 6.10.4-3 describes the connections required to support RS-232 communications. Refer to section 3.6.2.2, front panel test connector for the mating connector description and specification.

The RS-232 port requires the following characteristics: 19,200 Baud, 8 bits, No parity, and 1 stop bit.

PIN	FUNCTION
1	Ground (Smart Cable power return)
2	PCMCIA Card Present
3	RS232 RX
4	RS232 TX
5	Reserved
6	Smart Cable power
7	Smart Cable serial clock
8	Smart Cable serial input
9	Smart Cable serial output
10	Smart Cable serial select
11	GSE present
12	GND
13	GND
14	GND
15	Reserved

TABLE 6.10.4-2: MKVI/MKVIII EGPWC FRONT PANEL TEST PLUG PIN DESCRIPTION

EGPWC FRONT PANEL PLUG Connection Source	**PC, DB-9** Termination	**PC, DB-25** Alternate Termination
3 (Receive)	3 (Transmit)	2 (Transmit)
4 (Transmit)	2 (Receive)	3 (Receive)
1 (Ground)	5 (Ground)	7 (Ground)

TABLE 6.10.4-3: EGPWC FRONT PANEL RS-232 CONNECTIONS

6.10.5 Smart Cable (PCMCIA Interface)

The EGPWC Smart Cable is a removable PCMCIA interface (part number 951-0386-001). The Smart Cable is compatible with any ATA style cards. Table 6.10.5-1 identifies those PCMCIA cards that have been tested and approved for use with the Smart Cable.

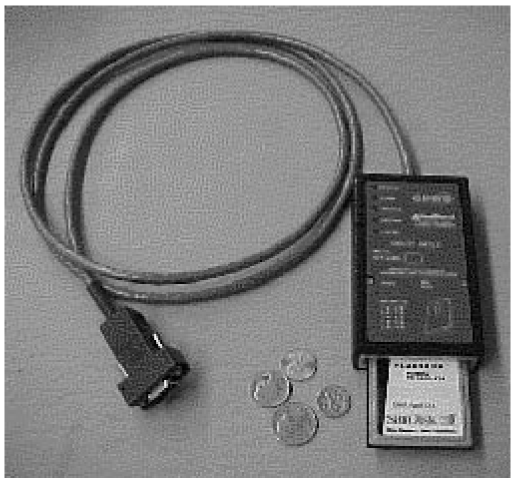


FIGURE 6.10.5-1: SMART CABLE, PART NUMBER 951-0386-001

PCMCIA CARD MANUFACTURER	**SIZE**	**VENDOR PART NUMBER**	**HONEYWELL PART NUMBER**
SanDisk ATA Flash Card	85MB	SDP3B-85-101	300-1126-014
SanDisk ATA Flash Card	85MB	SDP3BI-85-101	300-1141-003
SanDisk ATA Flash Card	220MB	SDP3B-220-390	300-1126-010
SanDisk ATA Flash Card	220MB	SDP3BI-220-390	300-1141-001

TABLE 6.10.5-1: APPROVED PCMCIA CARDS

The most common use of this interface is for upload of software and databases. The interface can also be used for download of accumulated history data. The loading operation will closely emulate that of an ARINC 615 data loader. Many safety checks are built in to prevent errors during the upload process. These include file identification codes, CRCs, date stamps, and version compatibility tests.

Adjacent to the PCMCIA slot on the Smart Cable there are four LED's. These LED's are operational only when the PCMCIA slot is being used to load data into or from the EGPWS. A diagram of these LED's and their location on the Smart Cable is shown in Figure 6.10.5-2:

Color		Label
Green	O	Power
Yellow	O	IN PROG
Yellow	O	CARD CHNG
Green	O	XFER COMP
Red	O	XFER FAIL

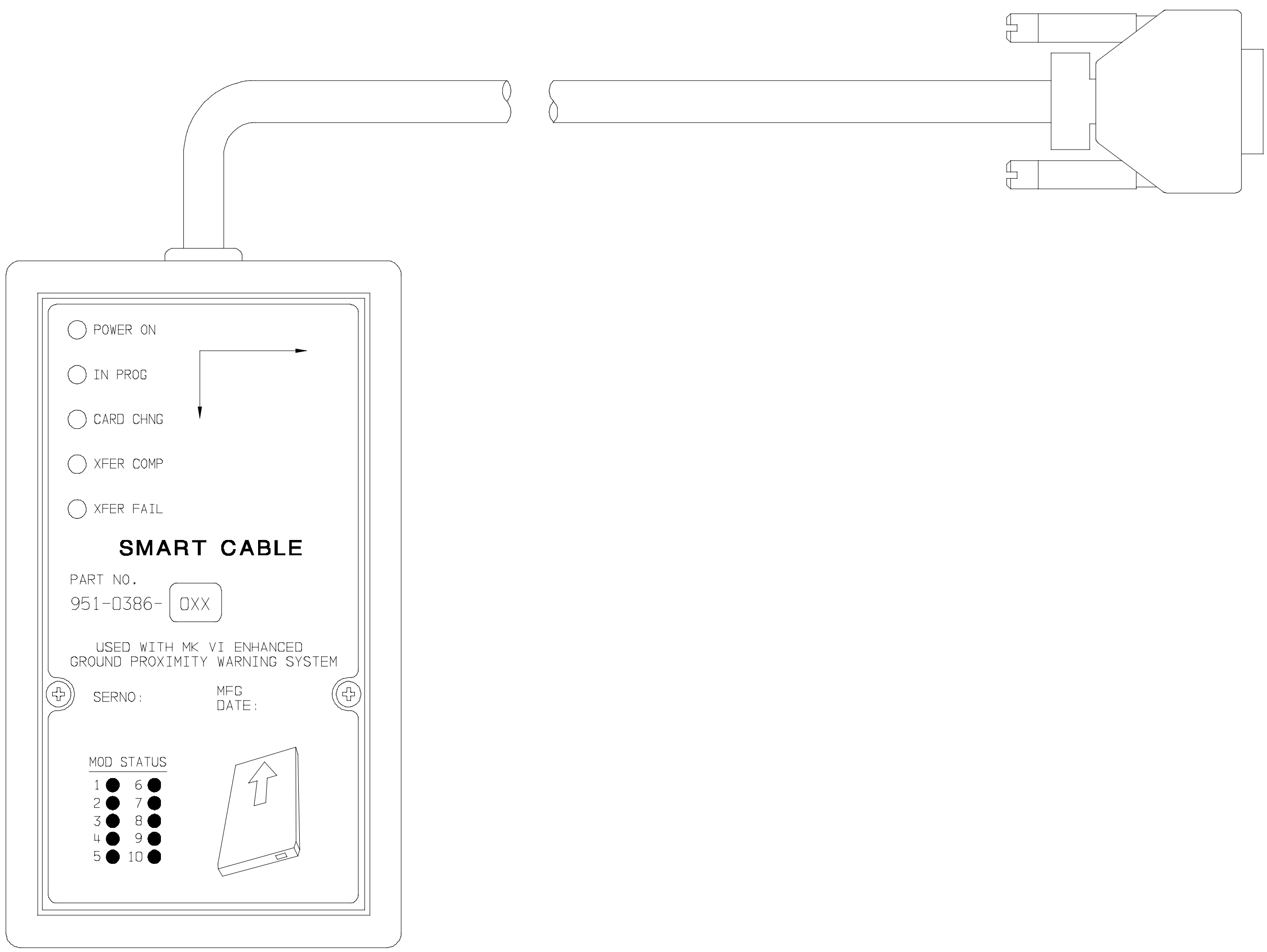


FIGURE 6.10.5-2: SMART CABLE SCHEMATIC

6.10.6 Self-Test

The EGPWC provides self-test capability on the ground. This provides an indication of the ability of the EGPWC to perform its intended function.

The EGPWC self-test is initiated by momentarily pressing the cockpit self-test button. The self-test results are annunciated, at 6db lower than the normal audio level selected for the aircraft, via the same audio system as the EGPWS alerts. The self-test has been divided into six different levels to aid in testing and troubleshooting of the EGPWC.

The self-test has six levels which are as follows:

Level 1 = Go / No Go Testing- provides an overview of the current operational functions selected and provides an indication of their operational status

Level 2 = Current faults - provides a listing of the internal and external faults currently detected by the EGPWC

Level 3 = EGPWS Configuration - indicates the current configuration by listing the current hardware, software, databases and configuration module options detected by the EGPWC

Level 4 = Fault history - provides a historical record of the faults both internal and external detected by the EGPWC

Level 5 = Warning history - provides a historical record of the warnings and cautions given by the EGPWS

Level 6 = Discrete Test - provides annunciation of discrete input transitions to be used for maintenance support

To expedite the navigation of self-test levels and information two types of cancel sequences are supported. Pressing and holding the cockpit self-test button for <u>less than 2 seconds</u> is considered a ***Short Cancel***. Pressing and holding the cockpit self-test button for <u>more than 2 seconds</u> is considered a ***Long Cancel***. The result of performing a short or long cancel is defined below for each self-test level.

Self-test is inhibited when steep approach is active (enabled and selected).

Self-test is exited if “In Air” becomes true.

Note: the EGPWS self-test is common to the MKV/VI/VII/VIII EGPWS and the Figures are generic to all. Functions not applicable to the MKVI/MKVIII EGPWS (e.g. windshear) are bypassed in the actual self-test operation.

6.10.6.1 Level 1 self-test

Level 1 self-test is divided into three functions - the preamble, short level 1 self-test and long level 1 self-test.

During level 1 self-test, a *Short Cancel* terminates the self-test level and “CURRENT FAULTS” is annunciated to indicate activation of level 2 self-test.

During level 1 self-test, a *Long Cancel* terminates the entire self-test sequence.

6.10.6.1.1 Preamble

In most conditions, self-test will operate and annunciate some indication as to the operational condition of the EGPWC, unless it has been inhibited, e.g. in-air (see Note). Self-test checks if configuration errors have been detected before it starts the main self-test process. The configuration module status, aircraft configuration database CRC, aircraft configuration database compatibility and the aircraft type are all checked prior to starting self-test. If any of these faults are detected, self-test will annunciate the detected fault and terminate the self-test process. The self-test preamble is initiated automatically upon self-test activation. The process and results are described in Figure 6.10.6-1.

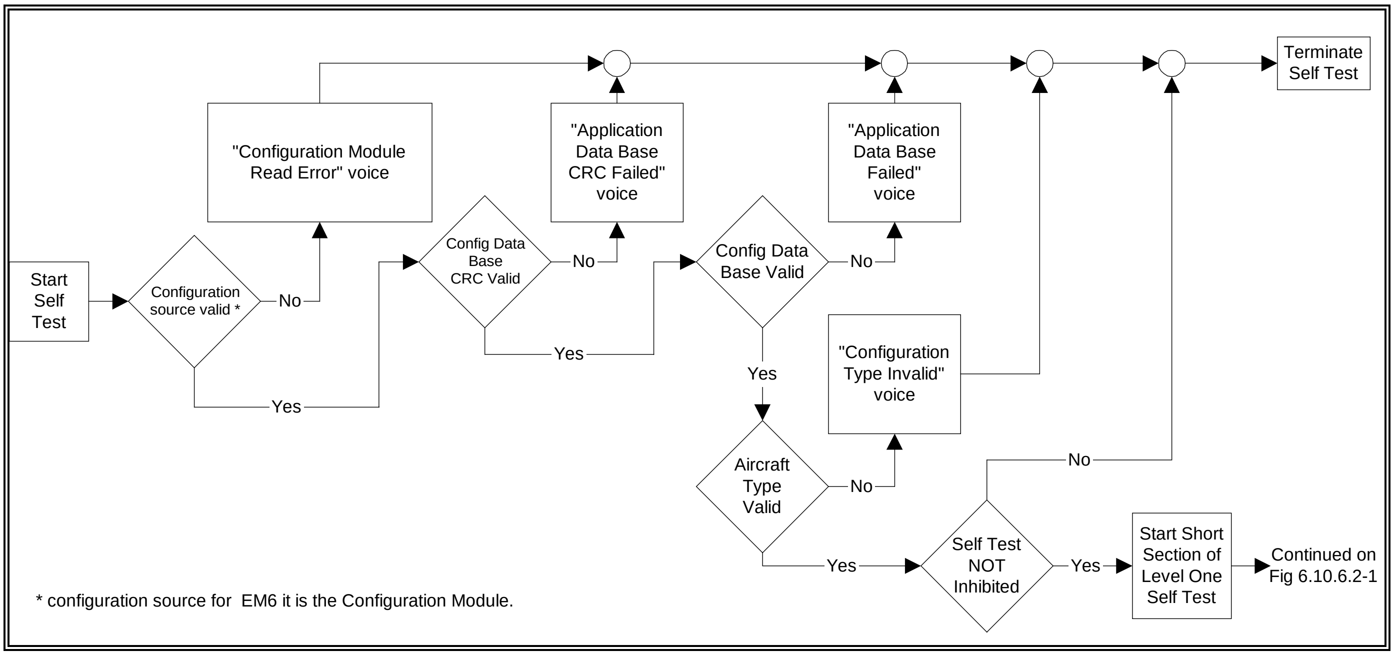


FIGURE 6.10.6-1: SELF-TEST PREAMBLE

6.10.6.1.2 Short Level 1 Self-Test

The short level 1 self-test is a subset of the long level 1 self-test. Short level 1 self-test is intended to provide a confidence, Go / No Go, test to show that the EGPWS is fully operational. It indicates which modes of the EGPWC are currently operational and which functions are not available. Short level 1 self-test is initiated immediately following the successful completion of the self-test preamble. The results are described in Figure 6.10.6-2.

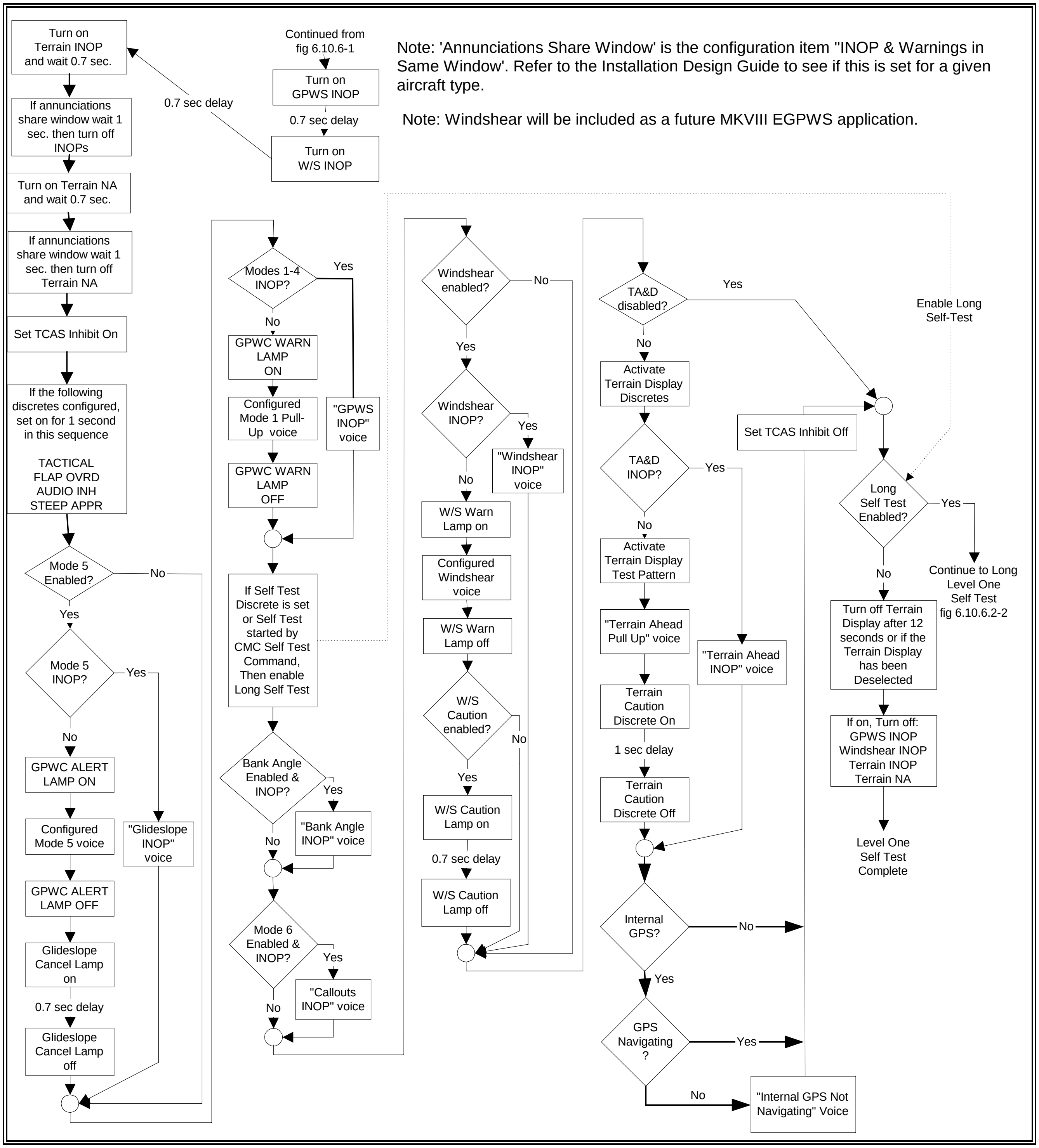


FIGURE 6.10.6-2: SHORT LEVEL 1 SELF-TEST

6.10.6.1.3 Long Level 1 Self-Test

The long level 1 self-test is initiated by pressing and holding the cockpit self-test button until self-test voices start. The long level 1 self-test annunciates all configured and activated alert voices, including warning voices, caution voices and altitude callout voices. If activated, the long level 1 self-test is initiated immediately following the short level 1 self-test. The results are described in Figure 6.10.6-3.

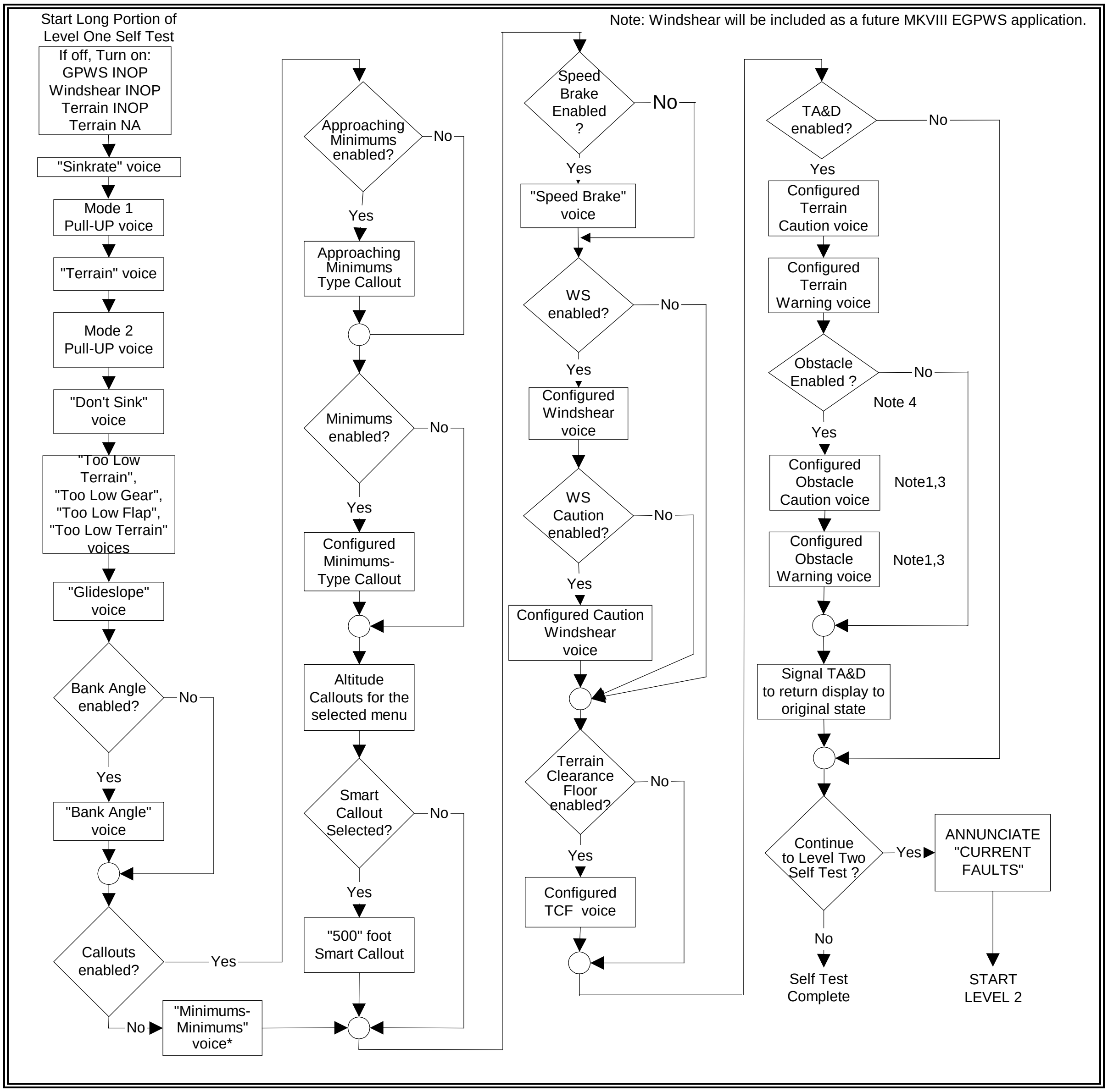


FIGURE 6.10.6-3: LONG LEVEL 1 SELF-TEST

6.10.6.2 Level 2 Self-Test - Current Faults

Level 2 self-test provides enunciation of all faults existing at the time of the request. Level 2 self-test is initiated by pressing the cockpit self-test button within 3 seconds of the end of level 1 self-test. The results are described in Figure 6.10.6-4.

During level 2 self-test, a *Short Cancel* or *Long Cancel* terminates the self-test level and "PRESS TO CONTINUE" is annunciated for proceeding to level 3 self-test.

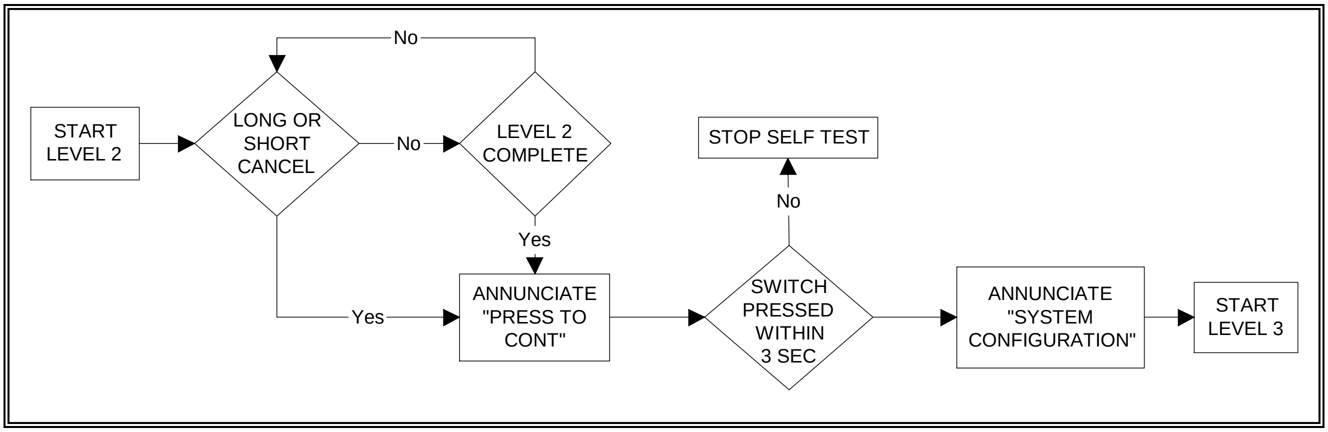


FIGURE 6.10.6-4: LEVEL 2 SELF-TEST

Note: "NO FAULTS" is annunciated at end of test if no faults present. Otherwise, the following will be annunciated

1) GPWS Computer OK or GPWS Computer Fault
2) Any Internal Faults
3) Any External Faults
4) Any System Status Messages

6.10.6.3 Level 3 Self-Test - System Configuration

Level 3 self-test provides enunciation of the system configuration present at the time of the request. Level 3 self-test is initiated by pressing the cockpit self-test button within 3 seconds of the end of level 2 self-test. The process is described in Figure 6.10.6-5 and includes the information as described in table 6.10.6-1.

During level 3 self-test, a *Short Cancel* bumps the enunciation to the next level 3 item (e.g. from terrain database information to Envelope Modulation database information).

During level 3 self-test, a *Long Cancel* terminates the self-test level and "PRESS TO CONTINUE" is annunciated for proceeding to level 4 self-test.

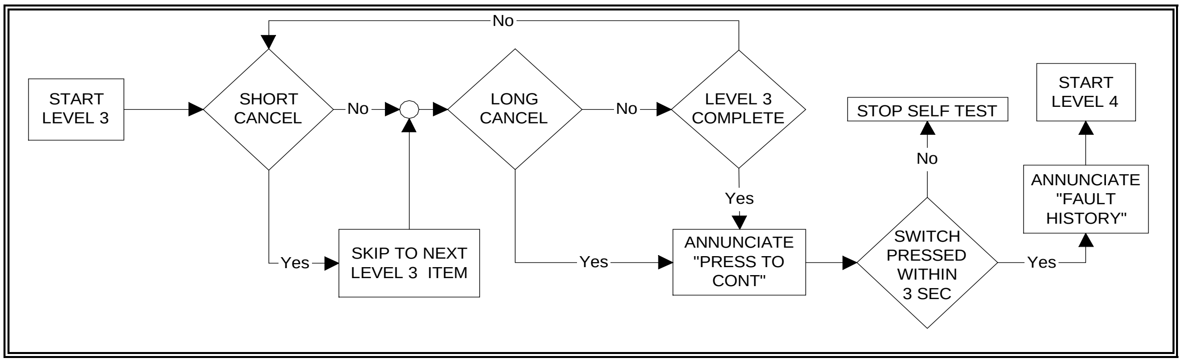


FIGURE 6.10.6-5: LEVEL 3 SELF-TEST

1.	Part Number
2.	Mod Status
3.	Serial Number
4.	Application Software Version
5.	Terrain Database Version
6.	Envelope Modulation Database Version
7.	Boot Code Version
8.	Aircraft Type
9.	Air Data Type
10.	Radio Altitude Type
11.	Navigation Input Type
12.	Attitude Input Type
13.	Magnetic Heading Type
14.	Position Input Type
15.	Callouts Option
16.	Audio Menu
17.	Volume Select
18.	Terrain Display Type
19.	IO Discrete Type
20.	Windshear Type
21.	All other selected options from the configuration module. Refer to MKVI/MKVIII EGPWS Installation Design Guide. Note that only those features that are enabled or disabled from the basic configuration are annunciated.

TABLE 6.10.6-1: LEVEL 3 SELF-TEST RESULTS

6.10.6.4 Level 4 Self-Test - Fault History

Level 4 self-test provides enunciation of the faults recorded over the last 10 flight legs. Level 4 self-test is initiated by pressing the cockpit self-test button within 3 seconds of the end of level 3 self-test. The process is described in Figure 6.10.6-6.

If any faults were recorded in the last ten legs then voice sequence as described in Table 6.10.6-2 will be annunciated. Otherwise the message "NO FAULTS" will be annunciated.

During level 4 self-test, a *Short Cancel* bumps the to the next flight leg with faults (if any).

During level 4 self-test, a *Long Cancel* terminates the self-test level and "PRESS TO CONTINUE" is annunciated for proceeding to level 5 self-test.

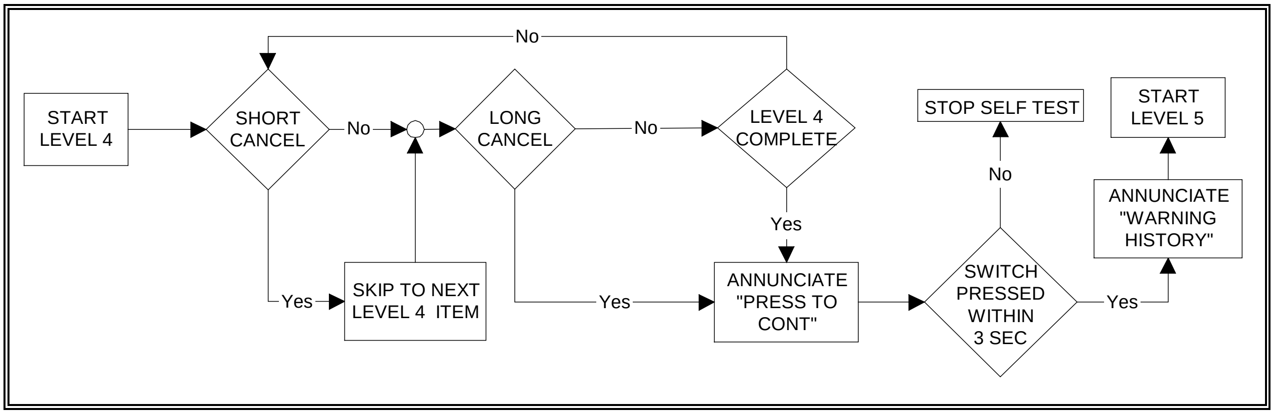


FIGURE 6.10.6-6: LEVEL 4 SELF-TEST

1.	Annunciate the number of the most recent flight leg with faults as "FLIGHT X", where "X" is a number from 1 to 10 where 1 is the most recent flight leg
2.	Annunciate any internal faults stored for leg X
3.	Annunciate any external faults stored for leg X
4.	Increment to next oldest leg with faults (if any) and repeat the above sequence

TABLE 6.10.6-2: LEVEL 4 SELF-TEST RESULTS

6.10.6.5 Level 5 Self-Test - Warning History

Level 5 self-test provides enunciation of the alerts (cautions and warnings) recorded over the last 10 flight legs. Level 5 self-test is initiated by pressing the cockpit self-test button within 3 seconds of the end of level 4 self-test. The process is described in Figure 6.10.6-7.

If any alerts were recorded in the last ten legs then voice sequence as described in Table 6.10.6-3 will be annunciated. Otherwise the message "NO WARNINGS" will be annunciated.

During level 5 self-test, a *Short Cancel* bumps the to the next flight leg with faults (if any).

During level 5 self-test, a *Long Cancel* terminates the self-test level and "PRESS TO CONTINUE" is annunciated for proceeding to level 6 self-test.

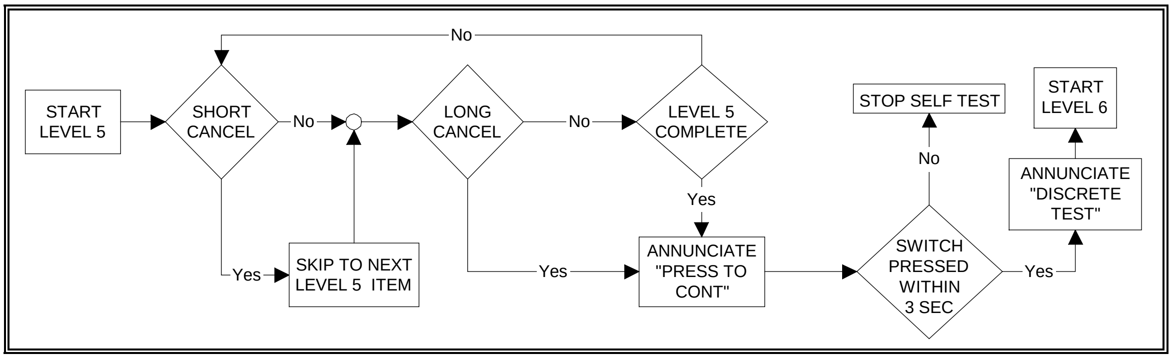


FIGURE 6.10.6-7: LEVEL 5 SELF-TEST

1.	Annunciate the number of the most recent flight leg with alerts as "FLIGHT X", where "X" is a number from 1 to 10 where 1 is the most recent flight leg
2.	Annunciate any alerts stored for leg X
3.	Increment to next oldest leg with alerts (if any) and repeat the above sequence

TABLE 6.10.6-3: LEVEL 5 SELF-TEST RESULTS

6.10.6.6 Level 6 Self-Test - Discrete Input Test

Level 6 self-test provides enunciation of any changes in the state of discrete inputs for the defined configuration. Changes in the state of the actual self-test discrete are not annunciated as it is directly tested in its use to control the test sequences. This feature is provided for production aircraft testing of discrete input. Level 6 self-test is initiated by pressing the cockpit self-test button within 3 seconds of the end of level 5 self-test. The results are described in Figure 6.10.6-8.

If state changes occur on any discrete input other than the self-test input, the functional name of the discrete (per the current configuration) will be annunciated using the string defined in the Installation Design Guide followed by its new state. For example, if the glideslope cancel discrete input in the current configuration is defined as ground = cancel, and the discrete transitions from open to ground, level 6 self-test will say: “GLIDESLOPE CANCELED”. If the input is only momentarily grounded level 6 self-test will say: “GLIDESLOPE CANCELED - GLIDESLOPE ENABLED.”

During level 6 self-test the message “DISCRETE INPUT TEST - PRESS TO CANCEL” is annunciated every 60 seconds. This provides additional evidence, along with the continued illumination of the INOP lights/fail annunciations, that self-test is still in progress. As with all self-test levels, if the aircraft goes “In Air”, then self-test is terminated.

During level 6 self-test, a *Short Cancel* or *Long Cancel* terminates the self-test level and “END OF SELF-TEST” annunciated.

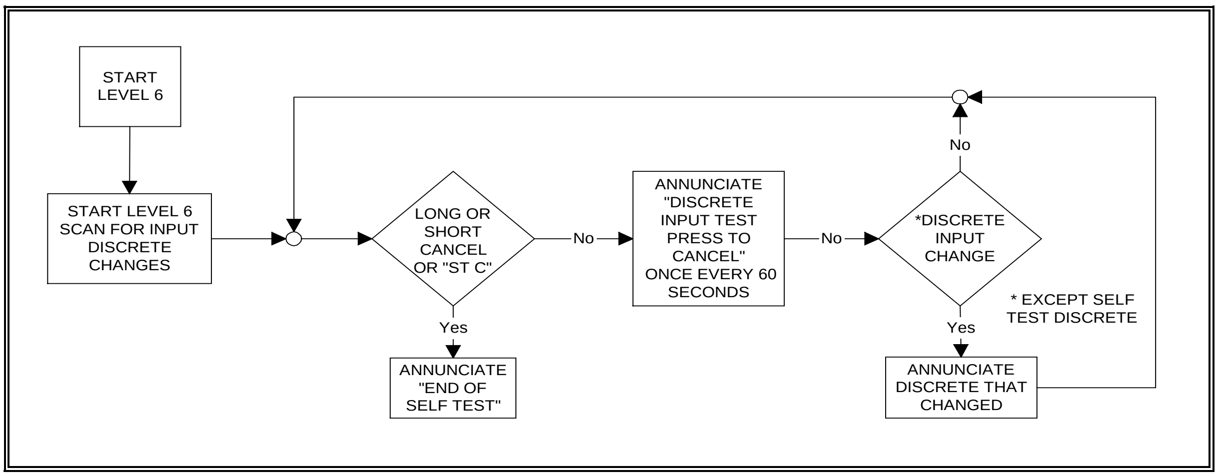


FIGURE 6.10.6-8: LEVEL 6 SELF-TEST

6.10.7 ATP

The Acceptance Test Procedure (ATP) for the EGPWC will be functional in nature, not designed to characterize the box. There is no requirement to produce a data sheet showing input thresholds or accuracy of internal processing. The ATP is not required to test any of the software or databases, other than to verify that they are present and operating. The EGPWC interface is defined by the Installation Design Guide, where the required inputs and the required output loading are defined. The most important thing to the customer is reasonable confidence that when the box is given its required inputs it will produce the stated outputs.

Testing is performed while connected to the EGPWS Ground Support Equipment (GSE) by inserting an ATP cartridge into the PCMCIA port on the smart cable, connecting the “run from PCMCIA” discrete, and turning the power on. The ATP cartridge contains code for the central processor that instructs it to report on the inputs and to generate signals used for checking the outputs. There is no special ATP software support outside of the ATP cartridge.

Refer to the EGPWC Hardware/Software Acceptance Procedure document, 076-0901-001, for EGPWC ATP requirements.

Refer to the applicable ATP, 076-0901-0xx, for requirements and instructions for performing the acceptance test.

6.10.8 BIT Tests

There exists within the EGPWC software Built In Test or BIT capability. Much of this BIT is continuously run, while some tests are run only as the result of certain events (e.g., power up). Failures are indicated via the EGPWS monitor output discrete, the ARINC 429 outputs, and system self-test and are saved in the flight history memory. Some BIT failures inhibit alerts. These cases will be apparent via the response to the system self-test.

For power up and cold start operations all of the possible BIT tests will be run.

At a minimum, BIT functionality will test/monitor the following areas/items:

CPU: The testing of the Central Processing Unit (CPU) will verify the non-random logic, control ROM, on-chip cache, and translation lookaside buffer (TLB) microprocessor functionality.

RAM: The Random Access Memory (RAM) and the RAM portion of the Non-Volatile Memory (NVM) will be tested to verify its addressing and data integrity.

Program Memory (ROM): This test performs a 32 bit CRC across the application code memory block and a pass/fail indication is written to the RS232 port.

Database Memory: This test performs a checksum of database and compares this value to a stored checksum value that was computed at the time of database release.

Non Volatile Memory (NVM): The non-volatile memory tests verify the read/write integrity of each location of EEPROM. These tests are non-destructive in that the existing data is restored at the end of the test.

NVM RAM Test: The random access memory portion (RAM) of the non-volatile memory will be tested to verify the read/write integrity of each location. These tests are non-destructive in that the existing data is restored at the end of the test.

Watch Dog Timer: The Watch Dog Timer test checks for proper operation of the watch dog timer used for software execution monitoring.

Analog to Digital Converter: Only the Analog to Digital or A/D Converter tests are performed for the analog inputs. These tests are performed only on installations where analog inputs are utilized.

Voice Generator: Voice Generator tests check the basic voice Digital Signal Processor (DSP) functionality, the ability of the host processor to boot up and communicate with the voice DSP, and the voice database integrity.

ARINC 429 Transmitter: These tests consist of verifying that the transmitter is able to empty its data buffer and responds properly to a handshaking flag which is passed between it and the main program software.

ARINC 429 Receiver: The ARINC 429 Receiver tests consist of internal parity checks on the 429 input data. ARINC 429 receiver faults and I/O addressing or data bus errors cause internal parity errors.

Software Task Monitor: This function monitors the various software tasks for fatal errors and takes the appropriate actions (i.e. shutting down the task) when an error is detected.

Input Signal Monitoring: All input signals will be monitored and any failed signals, busses, or LRU's will by identified.

Watchdog Monitor: The Watchdog Timer resets the processor when the software fails to complete its execution cycles in the specified amount of time.

Aircraft configuration database Monitor: The configuration database is monitored for database integrity.

Image DSP Tests: The Image DSP tests check the basic image Digital Signal Processor (DSP) functionality, the ability of the host processor to boot up and communicate with the image DSP.

Flight History Write Test: The flight history portion of the EGPWS memory will be tested for write integrity.

6.10.9 RS-232 Test Interface

There is an RS-232 input/output port on the front of each EGPWC for test control and data readout. This port serves as access to signal monitoring, flight history, initiating BITE tests, updating databases and other functions. The interface is intended for human interaction, but can also be used for custom interface programs such as the Honeywell VIEWS utility.

The RS-232 interface is used for test control and data readout functions and is available both in the air and on the ground. At power up, the EGPWS will begin polling the port for the RS-232 start up command. When the start up command, "^*Z*", is detected the port will become active. The port will remain active until the RS-232 end session command, "^*Y*", is given or until power is cycled.

The RS-232 interface supports the commands described in table 6.10.10-1.

The PC interface is described from the PC point of view. In the following descriptions, items in quotes are command line messages in ASCII/binary. The "<" and ">" symbols enclose parameters chosen by the user and are not literal values (e.g. <CR> indicates the Carriage Return key). Characters preceded with the carat (^) are an ASCII Control Character (i.e. "^A" is 0x01 hex NOT 0x41).

All commands must be terminated by a <*CR*>, except "^*Z*" and "^*Y*", and are NOT case sensitive.

Typing mistakes may be corrected using the <*BACKSPACE*> key.

The response to any invalid command is "INVALID COMMAND".

Command	Description
“^Z“	This command **Starts** (or re-starts after a “^Y”) each session. Upon receiving the *“^Z”* command the EGPWC provides a “>“ prompt indicating that the communication link has been established and the EGPWC is ready to accept other commands. No RS-232 communication is available until the *“^Z”* command has been provided.
“^Y”	This command **Ends** the RS-232 session. After entering a *“^Y”* only the *“^Z”* command is recognized.
“HELP“ ***“?“***	These commands displays **Help** information
“PS”	This command displays **Present Status** information. See section 6.10.13 for details on present status.
“CFG”	This commands enables the sub-monitor the configuration module is to be written to and read from. See section 6.10.16 for details on configuration module commands
“CMR”	This command reads the current configuration information from the configuration module. See section 6.10.16 for details on configuration module commands
“CMW <string>”	This command writes a CRC-protected string defining the configuration to the configuration module. See section 6.10.16 for details on configuration module commands
“CUW <string>”	This command writes an unprotected string defining the configuration to the configuration module. See section 6.10.16 for details on configuration module commands
“FHF”	This command displays the fault history information. See section 6.10.14.1 for details on fault history.
“FHI”	This command displays the **INOP History** information. See section 6.10.14.2 for details on INOP history.
“FHG”	This command displays the **Ground History** information. See section 6.10.14.3 for details on ground history.
“FHW”	This command displays the **Warning History** information. See section 6.10.14.4 for details on warning history.
“FHS”	This command displays the **Status History** information. See section 6.10.14.5 for details on status history.
“FHC”	This command displays the **Cumulative Counters** information. See section 6.10.14.6 for details on cumulative counters.
“FHE”	This command erases **Flight History**. The command is followed by the prompt *“ARE YOU SURE (Y/N)?”*. If the *“Y”*<CR> response is given, the EGPWC will erase all (but NOT the cumulative counters) of the flight history currently stored in memory. If the *“N”*<CR>, or <CR>, response is given, the EGPWC will NOT erase flight history and the EGPWC will await the next command. See section 6.10.3.6 for details on Flight history Erase. *NOTE: The “FHE” command will cause the EGPWC to re-boot. The “^Z” command must be re-sent after the re-boot sequence has completed.*
“GPS”	Displays status of internal GPS (when installed)
“ST” ***“ST 1”***	This command initiates the **Short Level 1 Self-Test**, just as if the self-test push button had been pushed. See section 6.10.6.1.2 for details on short level 1 self-test.
“ST L”	This command initiates the **Long Level 1 Self-Test**, just as if the self-test push button had been pushed. See section 6.10.6.1.3 for details on long level 1 self-test.
“ST <Level>“	Where “<Level>“ can be the number 2, 3, 4, 5 or 6. This command initiates the **Selected Self-Test Level**, just as if the self-test push button had been pushed. See section 6.10.6.2 through 6.10.6.6 for details on these self-test levels.
“ST C”	This command **Cancels** any self-test in progress
“VOI”	This command allows the user to type in any combination of supported EGPWC **Voices** to build a desired phrase and then the EGPWC shall annunciate the requested message. The words of the phrase must be separated by spaces.
“BI”	This command displays the **Board Identification** numbers for the following boards: controller card, accessory card, analog card, external interface card, and backplane card.

TABLE 6.10.10-1: RS-232 COMMANDS

The RS-232 port will default to the following characteristics: 19,200 baud, 8 bits, no parity, and 1 stop bit. The other potential baud rate settings is 38400. The baud rate 38400 will be used for file/database loading only.

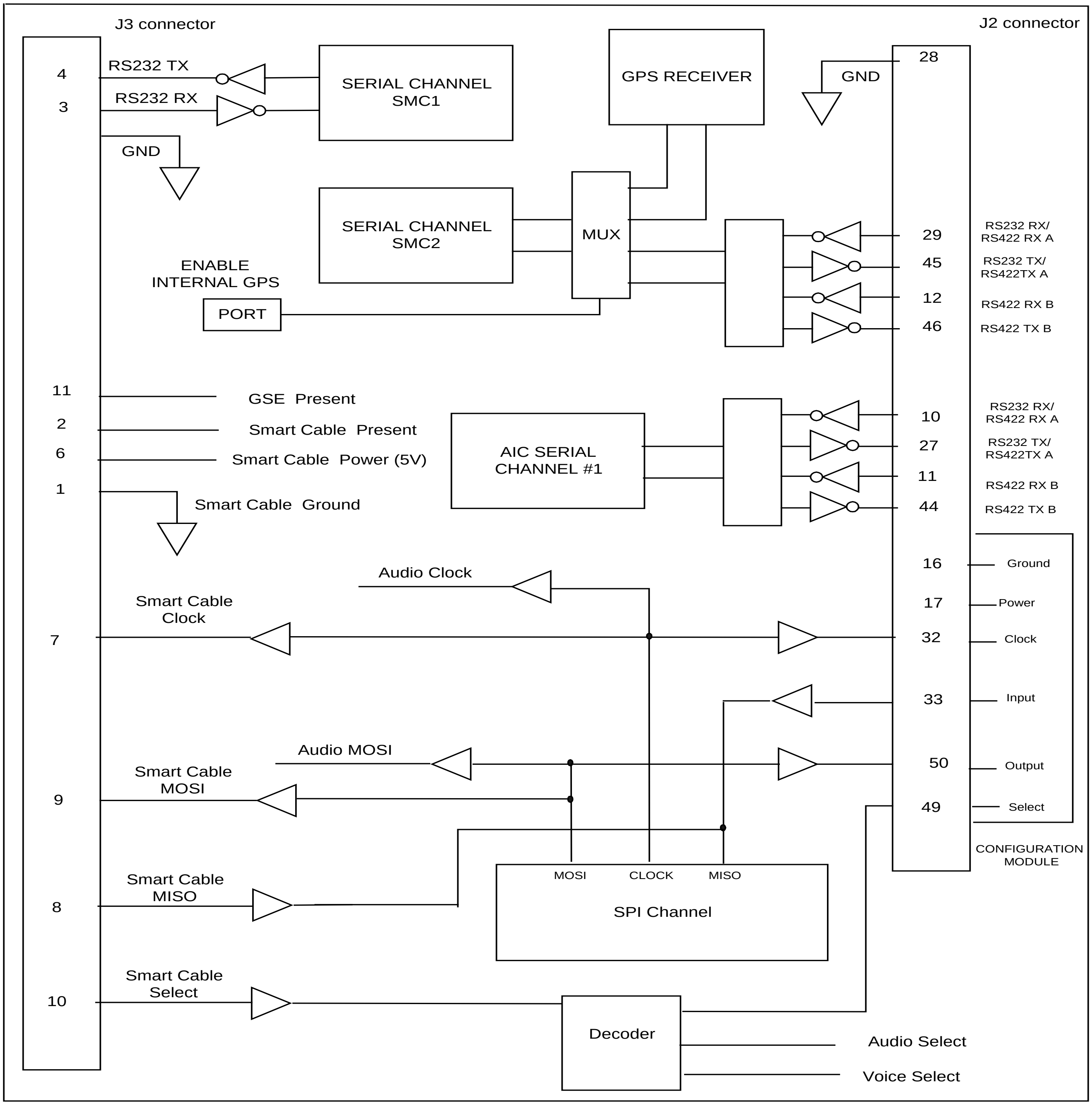
See section 6.10.4 for a description of the EGPWC front panel test plug connections required to support RS-232 communications.

6.10.10 Data Loading Interface

The EGPWC has the capability of having software, or databases, updated by using a PCMCIA card. (See Figures 6.10.10-1 MKVI/MKVIII EGPWS Serial I/O).

When Data Loading is allowed, all internal databases will be able to be loaded into the EGPWC via the data-loading interface. These databases include, but are not limited to, the following:

1) Terrain Database,
2) Runway Database,
3) Obstacle Database,
4) Configuration Database.
5) Envelope Modulation Database.



FIGURES 6.10.10-1 MKVI/MKVIII EGPWS SERIAL I/O

6.10.10.1 Data Loading Interface Formats

The data loading may be accomplished by using the PCMCIA (Smart Cable) interface.

6.10.10.2 General Operation/Protocols

The EGPWC will look for a valid Data Load RTS (Ready to Transmit Signal) continuously (at a specified period) while the aircraft is on the ground. Once a valid Data Load RTS is detected/received the EGPWC will acknowledge the request (as necessary) and then prepare/wait for the uploaded data. As the data is being read from the load source, the EGPWC will unlock the flash memory and overwrite the existing flash memory data locations (corresponding to the uploaded data files).

If an error occurs during data loading (i.e. there is a failed load), the EGPWC will NOT attempt to start the application software but will wait for a new dataload to commence and successfully complete.

Once the dataload is complete, the load request is cleared. If GSE is not present then the EGPWS will be rebooted. If GSE is present then the EGPWS will run the software previously present in RAM, without resetting the EGPWS or rebooting.

6.10.10.3 PCMCIA Data loading LED's

Adjacent to the PCMCIA slot on the smart cable there are four LED's which will be used for data loading activities. These lights are as defined in section 6.10.5.

The data loader LED's will be active only when a PCMCIA card is being used to load data. When active, the data loader LED's will mimic the performance of the lights on a portable data loader per the ARINC 615 standard.

6.10.11 Configuration Management and Version Identification

The purpose of version identification is to allow the factory and the customers to achieve configuration management as required by FAA regulations. The purpose of configuration management is to make sure that each installation contains/consists of all the pieces that it is supposed to contain: hardware, software, and database files.

The primary goal is to quickly, and easily determine the current configuration of a given EGPWC. A lesser goal is for the EGPWC to do the best job it can in protecting itself from incorrect configuration changes. Other goals include being able to determine current configuration without having to go into the electronics bay, and to be able to update a software configuration without removing the box from service.

There are two levels of version identification or configuration on the EGPWC. The first level of identification shows the configuration that has affect on the form, fit, or function of the EGPWC as seen by the pilot. This identification is accomplished via the EGPWC part number. The second level of identification provides information on terrain and Envelope Modulation database versions. Different terrain and Envelope Modulation database versions do not affect the form, fit, or function of the EGPWC as seen by the pilot.

In order to minimize complexity, the EGPWC utilizes a 10 digit part number. This 10-digit part number identifies the configuration of the EGPWC, which affects form, fit, or function as seen by the pilot.

The EGPWC is comprised of the following items or subcomponents:

- Hardware (including boot code)
- Application Software (including configuration software)
- Terrain Database
- Envelope Modulation Database

6.10.11.1 10 Digit Part Number Overview

In order to support manufacturing the EGPWC uses a 10 digit part number for production purposes via a 965-XXXX drawing. The 10-digit part number is defined in section 1.0 of this document.

6.10.11.1.1 Hardware

The hardware contains the following subcomponents:

- Boot code
- Controller Circuit Card Assembly
  - Main Processor
  - Analog Interface Processor
  - Image Generator DSP
- Power Supply Circuit Card Assembly
- Backplane Circuit Card Assembly

Each of the Circuit Card Assemblies (CCA) listed above have a “identification bit” scheme which software can utilize to report hardware identification.

6.10.11.1.2 Application Software

The application software contains the following subcomponents:

- Application code

- Configuration database.
- Voice Waveform database
- Image DSP programs

In self-test level 3 and RS-232 present status, the application software will report the versions of the application software (which includes the configuration database), terrain database, Envelope Modulation database, and boot code. In addition, the application software will report the EGPWC part number, modification status, and serial number.

If *Terrain Awareness* is enabled (Terrain Awareness is basic and must be disabled via configuration module), the application software will check "compatibility" between itself and the terrain database upon each power up or reboot of the EGPWC. The application software will determine if the terrain database is compatible.

If *Terrain Awareness* is enabled (Terrain Awareness is basic and must be disabled via configuration module), failure of the application software compatibility check with the terrain database will set *TA&D INOP* and force self-test level 2 to report "Terrain database incompatible".

For *Envelope Modulation*, the application software will check "compatibility" between itself and the Envelope Modulation database upon each power up or reboot of the EGPWC. The application software will determine if the Envelope Modulation database is compatible.

For Envelope Modulation a failure of the application software compatibility check with the Envelope Modulation database will set *Envelope Modulation INOP* and force self-test level 2 to report "Envelope Modulation database incompatible".

The configuration software contains the following subcomponents:

- Aircraft interface files
- Aircraft configuration files

6.10.11.1.3 Terrain Database

The Terrain database contains the following subcomponents:

- Terrain database
- Runway database

The terrain database may also include an obstacle database to activate the obstacle alerting feature.

The Terrain database has one version number accessible by the application software. For the MKVIII EGPWS this version number will be in the form of a 3 digits (e.g. 419). For the MKVI EGPWS this version number is four characters where the extra character indicates which region is present, e.g. 419N (Americas), 419A (Atlantic) or 419P (Pacific). The terrain database will have a compatibility index accessible by the application software.

6.10.11.1.4 Envelope Modulation database

The Envelope Modulation database has one version number accessible by the application software. The Envelope Modulation database will have a compatibility index accessible by the application software.

6.10.11.2 Software Updates

The details on how software updates are to be performed are described in section 6.10.11 data loading.

The implementation of software updates is as follows: When a software update (data load) is complete, the EGPWC uses and reports (via level 3 self-test and RS-232 present status) the updated software/database version(s).

6.10.11.3 ATP Configuration Management

The hardware part number must be stored in the EGPWC. The easiest way to store this part number is via the ATP.

During ATP the following will occur:

1) The ATP will provide a list of all possible EGPWC part numbers and modification status and prompt the test operator to select the part number & mod status of the EGPWC being tested.

2) The ATP will command the part number and the modification status to be stored in the NVM of the EGPWC.

3) The ATP will prompt the test operator to enter in the serial number of the EGPWC being tested. This serial number may be as few as 3 characters, to as many as 6 characters.

4) The ATP will command the serial number of the EGPWC being tested to be stored in the NVM of the EGPWC.

In addition, the EGPWC ATP performs a "final" check to ensure that the internal CCAs and software are correct for the indicated EGPWC part number.

6.10.11.4 Production Configuration Management

The application software, Envelope Modulation database and terrain database will be loaded into the EGPWC at the 965 production level. The loading will be done via PCMCIA card(s). The PCMCIA card(s) will contain the upload list and appropriate "canner" output. These files will be listed in the appropriate VDD and/or drawing which describes the programming of the PCMCIA card(s).

Boot code must be present prior to PCMCIA loads. If boot code resides in the EGPWC it can be updated with a PCMCIA load of boot software.

The other software loaded at the 965 production level can be loaded via separate PCMCIA cards or via one PCMCIA card. For future software updates (i.e. new configuration software) a separate PCMCIA card may be required so that just the new software (i.e. configuration software) can be loaded into fielded units. However, for production it will be most desirable to have all of the other software components loaded via one PCMCIA card.

6.10.12 Present Status Output Format

Present status information includes software and database versions, a listing of internal and external faults (if they exist), configuration item options selected. When requested this data will be output to the user. The present status is output once and then not updated, unless another request for present status is submitted.

EGPWS present status information is output in a manner that is consistent with the self-test output and the output of EGPWS Flight history information. Refer to section 6.10.2.2 for a description of possible faults.

When requested, the EGPWS will output present status information in the following order (each item is described in detail in the following subsections) and format:

1) Software & Database Version Numbers
2) Current Faults,
    a) Internal Faults (if any exist),
        i) Internal Fault 1
        ii) Internal Fault 2 (etc.)
    b) External Faults (if any exist),
        i) External Fault 1
        ii) External Fault 2 (etc.)
3) System Configuration
    a) Selected Options (A/C Type, Voice Menu, Callout Menu, etc)
    b) Other options selected (deviations from the default configuration).

An example of a present status output is shown below:

EGPWC CONFIGURATION

PART NUMBER:	<part number>
MOD STATUS:	<status number>
SERIAL NUMBER:	<serial number>
APPLICATION S/W VERSION:	<version number>
TERRAIN DATABASE VERSION:	<version number>
ENVELOPE MOD DATABASE VERSION:	<version number>
BOOT CODE VERSION:	<version number>

CURRENT FAULTS

GPWS COMPUTER OK

GPWS EXTERNAL FAULTS:

GPS BUS FAULT

CONFIGURATION:

AIRCRAFT TYPE	= X
AIR DATA TYPE	= X
RADIO ALTITUDE TYPE	= X
NAVIGATION INPUT TYPE	= X
ATTITUDE TYPE	= X
MAGNETIC HEADING TYPE	= X
POSITION INPUT TYPE	= X
CALLOUTS OPTION TYPE	= X
AUDIO MENU TYPE	= X
VOLUME SELECT	= X
TERRAIN DISPLAY TYPE	= X
IO DISCRETE TYPE	= X
WINDSHEAR INPUT TYPE (EMK8 only)	= X

Note: In the example output, the <version number>, <part number>, <status number>, and <serial number> are the numbers of the associated item. These numbers and EGPWS configuration Management is described in detail in section 6.10.11.

The version numbers of the software and databases currently installed in the EGPWS are the first items in the present status output.

The *current faults* portion of the present status provides a list of all faults existing at the time of the present status request. The EGPWS internal faults are listed first followed by the external faults (i.e. input failures). If no faults currently exist the EGPWS will output “NO FAULTS” under the current faults section. If only external faults exist, “GPWS COMPUTER OK” will be output in the *current faults* section.

Note: For external faults, all bus inactive and wiring faults (analog inputs) will be given first, followed by all individual signal faults not masked by activity faults.

The configuration section of the present status will list items that are selectable via the configuration module. This will include the aircraft type selected, the voice menu selected, the callout menu selected (all configuration categories), and each option selected which is not part of the default configuration.

6.10.13 Flight History Output Formats

When requested via the RS-232 commands (see section 6.10.9) the EGPWS will output the recorded flight history to the terminal screen. The format of the history outputs is described in the following sections. The standard requirements of RS-232 output (i.e. page breaks, etc.) still apply to these formats.

For all history displays except fault history, an <*operating time*> is displayed for each event. This operating time is the same as recorded in the cumulative counters of section 6.10.3.2.1 and represents the amount of time that that EGPWC has been powered up since manufacture. Therefore the operating time does not indicate the actual date or time that the event occurred.

For fault history, a <*Timestamp*> is displayed for each event indicating the time it occurred (if that data is provided) and will be in standard time format of hours, minutes, and seconds. If time is not available, then the timestamp will be output as “Not Available”.

NOTE: For the history output formats, words shown in quotation marks (i.e. “FAULT HISTORY: “) are the exact phrases that will printed on the PC screen, without the quotation marks. Items in the “<“ and “>“ symbols are data items which will be determined by the EGPWS and output to the PC screen.

6.10.13.1 Fault History Output Format

Fault history recording is described in detail in section 6.10.3.

When requested, the EGPWS will output fault history information in the following order and format:

“FAULT HISTORY:”

“FLIGHT LEG” <the most recent leg number with faults>
“GPWS COMPUTER FAULTS:” (if any exist),
Internal Fault 1 <*Timestamp*>
Internal Fault 2 (etc.) <*Timestamp*>
“GPWS EXTERNAL FAULTS:” (if any exist),
External Fault 1 <*Timestamp*>
External Fault 2 (etc.) <*Timestamp*>

“FLIGHT LEG” <the next most recent leg number with faults>
“GPWS COMPUTER FAULTS:” (if any exist),
Internal Fault 1 <*Timestamp*>
Internal Fault 2 (etc.) <*Timestamp*>
“GPWS EXTERNAL FAULTS:” (if any exist),
External Fault 1 <*Timestamp*>
External Fault 2 (etc.) <*Timestamp*>
etc.

If no internal or external faults are present in any of the recorded flight legs, the EGPWS will output “NO FAULTS” on the line immediately following “FAULT HISTORY:” and that will be the entire fault history output.

6.10.13.2 INOP History Output Format

INOP history is described in detail in section 6.10.3.2.2

When requested, the EGPWS will output INOP history information in the following order and format:

"INOP HISTORY:"

"FLIGHT LEG" <the most recent leg number with an INOP>
<INOP Event 1> *<Operating Time>*
"GPWS COMPUTER FAULTS:" (if any exist),
Internal Fault 1
Internal Fault 2 (etc.)
"GPWS EXTERNAL FAULTS:" (if any exist),
External Fault 1
External Fault 2 (etc.)
<INOP Event 2> *<Operating Time>*
"GPWS COMPUTER FAULTS:" (if any exist),
Internal Fault 1
Internal Fault 2 (etc.)
"GPWS EXTERNAL FAULTS:" (if any exist),
External Fault 1
External Fault 2 (etc.)
etc.
"FLIGHT LEG" <the next most recent leg number with an INOP>
<INOP Event 1> *<Operating Time>*
"GPWS COMPUTER FAULTS:" (if any exist),
Internal Fault 1
Internal Fault 2 (etc.)
"GPWS EXTERNAL FAULTS:" (if any exist),
External Fault 1
External Fault 2 (etc.)
etc.

If no INOP's are present in any of the recorded flight legs, the EGPWS will output "NO INOPS" on the line immediately following "INOP HISTORY:" and that will be the entire INOP history output.

The INOP event will be one of the identifiers listed in Table 6.10.3.2.2.T10.

6.10.13.3 Ground History Output Format

Ground history is described in section 6.10.3.4.

When requested, the EGPWS will output ground history information in the following order and format:

"GROUND HISTORY:"

<Ground history Event> *<Operating Time>*
"GPWS COMPUTER FAULTS:" (if any exist),
Internal Fault 1
Internal Fault 2 (etc.)
"GPWS EXTERNAL FAULTS:" (if any exist),
External Fault 1
External Fault 2 (etc.)

If no Ground history events exist, the EGPWS will output "NO EVENTS" on the line immediately following "GROUND HISTORY:" and that will be the entire ground history output.

The Ground history event text will be one of the following identifiers: "GPW INOP", "Mode 6 INOP", "Bank Angle INOP", "TA&D INOP", "Envelope Modulation INOP", "Present Status", or "Self-Test, Level 1".

6.10.13.4 Alert History Output Format

Alert history is described in detail in section 6.10.3.3.2

When requested, the EGPWS will output alert history information in the following order and format:

"WARNING HISTORY:"

"FLIGHT LEG" <the most recent leg number with an alert>
<Alert Event 1> *< Operating Time >*
<Alert Event 2> *< Operating Time >*
etc.
"FLIGHT LEG" <the next most recent leg number with a warning>
<Alert Event 1> *< Operating Time >*
etc.

NOTE: For a specific flight leg, <Alert Event 1> and <Alert Event 2> may be the same type of alert if that type of alert happened twice.

If no alerts are present in any of the recorded flight legs, the EGPWS will output "NO WARNINGS" on the line immediately following "WARNING HISTORY:" and that will be the entire alert history output.

The alert event will be one of those listed in Table 6.10.3.3.2.T10, with the actual voice is determined by the selected AAAS menu.

6.10.13.5 Status History Output Format

Status history is described in detail in section 6.10.3.5.

When requested, the EGPWS will output the status history information in the following order and format:

"STATUS HISTORY:"
"ENVELOPE MOD IN PROGRESS:"
"FLIGHT LEG" <the most recent leg number with an Env. Mod event> < *Operating Time* >
"FLIGHT LEG" <the next leg number with an Env. Mod event> < *Operating Time* >
etc.
"NEW PROGRAM PIN CONFIGURATION:"
"FLIGHT LEG" <the most recent leg number with a configuration module event> < *Operating Time* >
"FLIGHT LEG" <the next leg number with a configuration module event> < *Operating Time* >
etc.
"TAKEOFF:"
"FLIGHT LEG" <the most recent leg number with a Takeoff event> < *Operating Time* >
"FLIGHT LEG" <the next leg number with a Takeoff event> < *Operating Time* >
etc.
"LANDING:"
"FLIGHT LEG" <the most recent leg number with a Landing event> < *Operating Time* >
"FLIGHT LEG" <the next leg number with a Landing event> < *Operating Time* >
etc.
"TA NOT AVAILABLE (ON):"
"FLIGHT LEG" <the most recent leg number with a TA Not Avail. On event> <*Operating Time*>
"FLIGHT LEG" <the next leg number with a TA Not Avail. On event> <*Operating Time*>
etc.
"TA NOT AVAILABLE (OFF):"
"FLIGHT LEG" <the most recent leg number with a TA Not Avail. Off event> <*Operating Time*>
"FLIGHT LEG" <the next leg number with a TA Not Avail. Off event> <*Operating Time*>
etc.
"TERRAIN INHIBIT (ON):"
"FLIGHT LEG" <the most recent leg number with a Terrain Inhibit On event> <*Operating Time*>
"FLIGHT LEG" <the next leg number with a Terrain Inhibit On event> <*Operating Time*>
etc.
"TERRAIN INHIBIT (OFF):"
"FLIGHT LEG" <the most recent leg number with a Terrain Inhibit Off event> <*Operating Time*>
"FLIGHT LEG" <the next leg number with a Terrain Inhibit Off event> <*Operating Time*>
etc.

If no status events are present in any of the recorded flight legs, the EGPWS will output "NO STATUS EVENTS" on the line immediately following "STATUS HISTORY:" and that will be the entire status history output. Only the last 100 of each kind of Terrain Awareness not available events and terrain inhibit events are displayed.

6.10.13.6 Cumulative Counters Output Format

The cumulative counters are described in detail in section 6.10.3.2.1 and section 6.10.3.3.1.

When requested, the EGPWS will output the EGPWS cumulative counter information in the following order and format:

"WARNING COUNTERS:"
In this table 'Voice' refers to the actual warning voice given by the EGPWS (i.e. "Pull Up").

<count>	-	Mode 1 Outer Curve Voice
<count>	-	Mode 1 Inner Curve Voice
<count>	-	Mode 2 Terrain Voice
<count>	-	Mode 2 Pull-Up Voice
<count>	-	Mode 3 Voice
<count>	-	Mode 4 Too Low Terrain Voice
<count>	-	Mode 4 Too Low Gear Voice
<count>	-	Mode 4 Too Low Flap Voice
<count>	-	Mode 4 Too Low Terrain Voice
<count>	-	Mode 5 Voice
<count>	-	Mode 6 Bank Angle Alert
<count>	-	Terrain Clearance Floor Voice
<count>	-	Terrain Awareness Caution
<count>	-	Terrain Awareness Pull Up
<count>	-	Obstacle Awareness Caution
<count>	-	Obstacle Awareness Pull Up

"ACTIVITY COUNTERS:"

<count>	-	"Glideslope Cancel"
<count>	-	"Number of Flights"
<time>	-	"GPW INOP Time"
<time>	-	"TA&D INOP Time"
<time>	-	"TA&D Not Available Time"
<time>	-	"Terrain Inhibit Time"
<time>	-	"Flight Time"
<time>	-	"Operating Time"

NOTE:

Since the warning counters are not incremented until an air to ground transition takes place, it is possible for these counts to be in a "pending" condition while the aircraft is in flight. This condition indicates that a warning or caution has occurred, but the counter has not been incremented because the aircraft is still airborne. When a counter is in this state the '-' character between the count and the descriptive text is changed to 'P' (to denote "pending"). There is no equivalent state for the Activity Counters.

The <count> or <time> is the ongoing cumulative count or time for the specified event. *time* will be formatted as in hours, minutes, and seconds.

6.10.14 Internal GPS Status Format

The EGPWS will be capable of displaying the status for up to eight visible satellites being tracked on the eight channels of the receiver. Note that if the receiver is tracking less than eight satellites, the unused satellite ID's will be set to zero. The data will be collected from the receiver and when requested this data will be output to the user. The GPS status is output once and then not updated, unless another request for GPS status is submitted. Assuming no RS232 communications faults the information will be formatted as shown below.

XPRESS GPS STATUS:
RS-232 COMMUNICATION OK
STATE: <*state*>

INTEGRITY STATE: 0x00 MASKED INTEGRITY WARNING: 0x00
BAD COVERAGE: 0x00 ALTITUDE AIDING IN USE: 0x00
NAV MODE: 0x00 ERROR STATUS: 0x408

NUMBER OF SATELLITES TRACKING: 08

CHANNEL	SAT ID	SNR	ELEV	AZM	HEALTH	TRACKING
1	18	45	13	45	3	1
2	31	47	38	120	3	1
3	7	40	10	16	3	1
4	19	47	52	22	3	1
5	27	44	83	151	3	1
6	2	46	56	134	3	1
7	13	48	62	8	3	1
8	10	42	16	64	3	1

State can be one of the following:
INITIALIZATION
SEARCH THE SKY
ACQUISITION
TRANSITION
NAVIGATION
NAVIGATION WITH POSSIBLE DATA COLLECTION
NAVIGATION WITH POSITION DEGRADATION
DEAD RECKON

When a RS232 problem exists the following information will be provided:

XPRESS GPS STATUS:
RS-232 COMMUNICATION FAULT - <*RS-232 Xpress faults*>

RS-232 Xpress faults can be one of the following:
RECEIVER INACTIVE
TRANSMIT ERROR

MISSING PACKET(S)
CHECKSUM ERROR

6.10.15 Configuration Module Programming via RS-232

The application code is capable of loading the configuration module with new data.

This programming is achieved using the keyboard monitor. The ‘^Z’ command from the keyboard is used to activate the keyboard command and allow the EGPWS to accept valid commands. To prevent inadvertent access to the configuration module’s EEPROM the keyboard monitor is set up with a tiered menu. The keyboard monitor command ‘CFG’ is used to gain access to the configuration Monitor.

The commands to program the memory are ‘CMW’ or ‘CUW’. ‘CMW’ takes a pre–conFigured string (defined in section 6.10.15.1) containing the new memory contents and a CRC and writes them to the configuration module’s EEPROM per section 6.10.16.4. ‘CUW’duplicates this but the CRC process is invisible to the user since it is added by the EGPWC.

6.10.15.1 Configuration Module Memory Map

The memory map is will provide the format of the configuration data stored in the configuration module.

The configuration module EEPROM memory will have contents stored in a definite format.

Each time the memory is read the whole contents are transferred to the EGPWC. When the memory is programmed (written to) the whole contents must be transferred to the configuration module or an individual category can be updated (not forgetting that the CRC must also be updated. The memory map is defined in Table 6.10.15.1-1.

Memory Block	Sub-string Name	Reference
String Format Version	String Format Version	6.10.15.1.1
Data Block	Data String	6.10.15.1.1
CRC Block	CRC String	6.10.15.1.1

TABLE 6.10.15.1-1 CONFIGURATION MODULE MEMORY MAP

6.10.15.1.1 String Format Version

The string format version identifier is used to identify when the format of the entire string changes.

For example if extra information (such as software version or hardware version) were to be added to the user block this would necessitate a change to the format of the user block, since this information is not related to the configuration items. A change to the number of configuration items does not require a change in the string format version since the number of configuration items (identified by the user block) accommodates this already.

The data block details the configuration data. The length of this block is limited only by available memory. For string version 0, the *Data Block* will include the number of configuration items, as defined in the MKVI/MKVIII EGPWS Installation Design Guide for the current application.

The CRC block contains the result of a 32-bit CRC on the contents of the string format version identifier and user blocks (excluding separators). The length of this block is dependent on the type of integrity check. This block is pre-calculated in the PC tool that creates the data for download to the configuration module. The memory contents are fed into a software 32-bit CRC and the result checked against this block. This block is only used by the ‘CMW’ command, not the ‘CUW’ command.

String Format Version	**String Format Version (1 byte)**
Data Block	**Number of Categories (1 byte)**
	Category 1 (1 byte)
	Category 2 (1 byte)
	Category 3 (1 byte)
	. . .
	Last Category (1 byte)
CRC String	**CRC String (4 bytes)**

TABLE 6.10.15.1.1-1 STRING FORMAT VERSION ZERO FOR CMW COMMAND

String Format Version	**String Format Version (1 byte)**
Data Block	**Number of Categories (1 byte)**
	Category 1 (1 byte)
	Category 2 (1 byte)
	Category 3 (1 byte)
	. . .
	Last Category (1 byte)

TABLE 6.10.15.1.1-1 STRING FORMAT VERSION ZERO FOR CUW COMMAND

Note: In the <user input string> the *String Format Version*, *Data Block* and *CRC String* will be separated by the '/' character. Parsing within the *Data Block* will be done using a ' ' (space) character.

6.10.15.2 Configuration Module Read

The EGPWC requires the configuration information to be read from the configuration module each power up. The integrity of the read configuration data will be checked using a 32-bit CRC prior to comparison against the current NVM configuration. If the data to be written to the configuration module fails the 32-bit CRC check, the read process shall be restarted for up to four attempts.

If a configuration change is sensed from the current NVM configuration, then two consecutive reads of the configuration module must yield matching results before configuration can continue. If the first read matches the NVM version, then the system can configure immediately.

For user requested reads of the configuration module the values of each category and the CRC will be returned.

6.10.15.3 Configuration Module Write (CMW)

The EGPWS requires a string of configuration information to be written to the configuration module memory when requested from the keyboard monitor.

The user input string to be written to the configuration module will be checked using a 32-bit CRC prior to being written to the configuration modules EEPROM. For the CMW command the user enters this CRC. This string would read for example:

CMW 0/14 0 5 6 0 0 1 30 0 0 0 0 0 0 0/1919913334

Where the first zero reflects the sting version, the next number is the number of categories and the remaining numbers before the second separator reflect the ID for each of the categories. The 10-digit (in this case) number is the CRC.

After being written to EEPROM, the configuration module data will be read back. If this data fails the 32-bit CRC it will be taken to indicate the data write to the EEPROM failed, and the write process shall be restarted for up to four attempts.

After programming the memory locations, the EEPROM will be read per section 6.10.15.2 to confirm a successful data transfer to the configuration module occurred. After confirmation of the data integrity in the configuration module the EGPWS shall be rebooted to ensure that the EGPWS NVM is updated with the new configuration information.

6.10.15.4 Configuration Module Write (CUW)

The EGPWS requires a string of configuration information to be written to the configuration module memory when requested from the keyboard monitor.

The user input string to be written to the configuration module will be checked using a 32-bit CRC prior to being written to the configuration modules EEPROM. For the CUW command, this CRC is generated by the EGPWS rather than the user.

This string would read for example:

CUW 0/14 0 5 6 0 0 1 30 0 0 0 0 0 0 0 0/

Where the first zero reflects the sting version, the next number is the number of categories and the remaining numbers before the second separator reflect the ID for each of the categories.

After being written to EEPROM, the configuration module data will be read back. If this data fails the 32-bit CRC it will be taken to indicate the data write to the EEPROM failed, and the write process shall be restarted for up to four attempts.

After programming the memory locations, the EEPROM will be read per section 6.10.15.2 to confirm a successful data transfer to the configuration module occurred. After confirmation of the data integrity in the configuration module the EGPWS shall be rebooted to ensure that the EGPWS NVM is updated with the new configuration information.

6.10.15.5 Configuration Module Faults

The configuration module will set faults associated with the read and write processes and also relating to the information contained in memory.

If the configuration module is present but contains no data, then the configuration module is indicated to be unprogrammed. If there is also no last valid NVM configuration (new box), then the system will configure to a zero default configuration.

If the number of categories present in the configuration module is more than the number expected by the software this will be faulted. If the number of categories present in the configuration module is less than the number expected by the software then the extra categories will be set to zero in NVM.

Note: Where there are less categories than expected in the configuration module, the configuration module will not have these categories added automatically. It is required that the user update the configuration module with this extra information.

Appendices

Appendix A: Definitions

The following acronyms are used in this document:

Acronym	Interpretation
AAAS	Alternate Audio Alert Select
ADC	Air Data Computer
ADS	Air Data System
AGL	Above Ground Level
AHRS	Attitude Heading Reference System
MSL	Mean Sea Level
ATA	Advanced Technology Attachment
ATP	Acceptance Test Procedure
BCD	Binary Coded Decimal
BIST	Built in Self Test
BIT	Built In Test
BITE	Built In Test Equipment
BNR	Binary
BOSS	Batch Oriented Simulation System
C/O	Callouts
CAA	Civil Aviation Authority
CFIT	Controlled Flight Into Terrain
CFM	Cubic Feet per Minute
COTS	Commercial Off The Shelf
CP	Control Panel
CRS	Course
CW	Clockwise
DAA	Digital/Analog Adapter
DADC	Digital Air Data Computer
DAU	Data Acquisition Unit
DC	Digital Command
DDM	Difference in Depth of Modulation
DEVN	Deviation
DH	Decision Height
DITS	Digital Information Transfer System
DME	Distance Measuring Equipment
DO	Discrete Output
DSP	Digital Signal Processor
DSU	Display Switching Unit
DSWC	Digital Stall Warning Computer
EEPROM	Electrically Erasable Programmable Read Only Memory
EFCP	EFIS Control Panel
EFIS	Electronic Flight Instrument System
EGPWC	Enhanced Ground Proximity Warning Computer
EGPWD	Enhanced Ground Proximity Warning Display
EGPWS	Enhanced Ground Proximity Warning System
EICAS	Engine Indication and Crew Alert System
EMI	Electromagnetic Interference
ENB	Enabled
EPROM	Erasable Programmable Read Only Memory
F/T	Functional Test
F/W	Fail/Warning
FAA	Federal Aviation Administration
FCC	Flight Control Computer
FDR	Flight Data Recorder
FIAS	Flight Inspection Aircraft System
FMC	Flight Management Computer
FMS	Flight Management System

Acronym	Interpretation
FPM	Feet per Minute
FSEU	Flaps/Slats Electronic Unit
FWC	Fault Warning Computer
G/S	Glideslope
GMT	Greenwich Mean Time
GPS	Global Position System
GPW	Ground Proximity Warning
GPWS	Ground Proximity Warning System
GT	Greater Than
H/W	Hardware
HDG	Heading
HDOP	Horizontal Dilution of Position
HSID	Hardware/Software Interface Document
I/O	Input/Output
IAC	Integrated Avionics Computer
ILS	Instrument Landing System
INOP	Inoperative
IOC	Input/Output Concentrator
ISO	International Standards Organization
IVS	Inertial Vertical Speed
KT	Knots
KTS	Knots
LED	Light Emitting Diode
LRRA	Low Range Radio Altimeter
LRU	Line Replaceable Unit
LSB	Least Significant Bit
LT	Less Than
MCP	Mode Control Panel
MDA	Minimum Barometric Altitude
MFD	Multi-Functional Display
MKII	Mark Two Warning Computer
MKVI	Mark Six Warning Computer
MKVIII	Mark Eight Warning Computer
MLS	Microwave Landing System
MSB	Most Significant Bit
N/A	Not Applicable
NCD	No Computed Data
ND	Navigation Display
NVM	Non Volatile Memory
OMS	Onboard Maintenance System
P/N	Part Number
PAR	Parity
PC	Personal Computer
PCMCIA	Personal Computer Memory Card Industry Association
PFD	Primary Flight Display
PMAT	Portable Maintenance Access Terminal
PP	Program Pin
PVM	Processor/Voice/Memory
PWS	Predictive Windshear System
QFE	Corrected Baro Alt relative to field elevation
QNH	Corrected Baro Alt relative to sea level
RA	Radio Altitude
RAM	Random Access Memory
RDOP	Radar Display Output Processing
ROM	Read Only Memory
RTCA	Requirements and Technical Concepts for Aviation
RTS	Ready to Transmit Signal
RWY	Runway
S/T	Self Test

Acronym	Interpretation
S/W	Software
SDI	Source/Destination Identifier
SDRD	Software Design Requirements Document
SIG	Significant
SPC	Stall Protection Computer
SRD	System Requirements Document
SSM	Sign Status Matrix
ST	Self Test
SWC	Stall Warning Computer
TACAN	Tactical Air Navigation
TAD	Terrain Awareness Display
TA&D	Terrain Awareness & Display
TBD	To Be Determined
TCAS	Traffic Collision Avoidance System
TCF	Terrain Clearance Floor
TERPS	United States' Standards for Terminal Instrument Procedures
TK	Track
TLB	Translation Lookaside Buffer
TSO	Technical Standing Order
TTL	Tuned To Localizer
UART	Universal Asynchronous Receiver Transmitter
USM	Unsigned Magnitude
UTC	Universal Time Correlation
UUT	Unit Under Test
VDC	Volts, DC
VDOP	Vertical Dilution of Precision
VHF	Very High Frequency
VLSI	Very Large Scale Integrated Circuit
VOR	VHF Omni-directional Range
W/S	Windshear
WC	Warning Computer